



LAWRENCE  
LIVERMORE  
NATIONAL  
LABORATORY

**UCRL-MI-231660**

**Marshall Islands Program  
Field Operations Report**

**Rongelap Island Geographical  
Information System (GIS) Sample Site  
Mapping**

**J.L. Brunk**

**S.R. Kehl**

**T.F. Hamilton**

**January 2007**

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

**Marshall Islands Program  
Field Operations Report**

**Rongelap Island Geographical  
Information System (GIS) Sample  
Site Mapping**

**J.L. Brunk, S.R. Kehl, and T.F. Hamilton**

**Lawrence Livermore National Laboratory  
Livermore, CA, 94551  
U.S.A.  
(hamilton18@llnl.gov)**

**January 2007**

## Table of Contents

Overview .....	01
Geographic Control .....	02
Radiological Survey Points around New Housing .....	02
Lagoon Road Radiological Survey Points .....	13
Existing Radiological Survey Points .....	22
New Geographic Control Points .....	22
Acknowledgment .....	22
Appendix I. GPS File Archive.....	A-1
Appendix II. GIS Metadata Summary Information.....	A-5

## List of Figures

<b>Figure 1.</b> New home sites on Rongelap Island -----	03
<b>Figure 2.</b> House 950 on Rongelap Island -----	04
<b>Figure 3.</b> House 951 on Rongelap Island -----	05
<b>Figure 4.</b> House 952 on Rongelap Island-----	06
<b>Figure 5.</b> Houses 953 and 954 on Rongelap Island-----	07
<b>Figure 6.</b> Houses 955, 956 and 957 on Rongelap Island -----	09
<b>Figure 7.</b> Newly renovated Church on Rongelap Island-----	11
<b>Figure 8.</b> Piggery site on Rongelap Island-----	12
<b>Figure 9.</b> The upper lagoon road on Rongelap Island -----	14
<b>Figure 10.</b> The lower lagoon road on Rongelap Island-----	16
<b>Figure 11.</b> Outline of the total mapping project on Rongelap Island (Feb.- March 2006) -----	23

## List of Tables

<b>Table 1.</b> Points around House 950 -----	04
<b>Table 2.</b> Points around House 951 -----	05
<b>Table 3.</b> Points around House 952 -----	06
<b>Table 4.</b> Points around House 953 -----	08
<b>Table 5.</b> Points around House 954 -----	08
<b>Table 6.</b> Points around House 955 -----	10
<b>Table 7.</b> Points around House 956 -----	10
<b>Table 8.</b> Points around House 957 -----	10
<b>Table 9.</b> Points around Church -----	11
<b>Table 10.</b> Points around the piggery -----	12
<b>Table 11.</b> Upper road points-----	15
<b>Table 12.</b> Sampling tree row markers-----	16
<b>Table 13.</b> Lower road points-----	17
<b>Table 14.</b> Files taken during this mission-----	A-2



# **Rongelap Island Geographical Information System (GIS) Sample Site Mapping**

J.L. Brunk, S.R. Kehl, and T.F. Hamilton  
Lawrence Livermore National Laboratory  
Livermore, CA, 94551  
U.S.A.

---

## **Overview**

Rongelap Atoll is located in the Republic of the Marshall Islands at approximately 11.1°N, 166.8°E. During March of 1954, the atoll was contaminated by radioactive fallout from the Bravo test detonated at Bikini Atoll about 70 miles to the west of Rongelap. The local inhabitants were immediately evacuated but returned 3 years later. In 1985, the people of Rongelap decided to leave their ancestral homeland because of continuing fear about exposure to residual contamination on the atoll. Under a new cooperative agreement between the U.S. Department of Energy, the Rongelap Atoll Local Government and the Republic of the Marshall Islands, Livermore scientists have recently been engaged in a new resettlement initiative on Rongelap. As part of this program, we provide verification monitoring of the clean-up programs to reduce external gamma exposure rates and the uptake of radionuclides in the locally grown foods. Beginning in 1999 and continuing to the present, several survey trips have been made to measure the progress of the clean-up effort. Over this period, hundreds of sampling points have been identified and mapped. During late February and early March of 2006, several new sampling points were added to the inventory including locations reconnoitered around home construction sites. Additionally, three new permanent control points were established.

Mapping was done with the Trimble Pro XR system. This system provides sub meter accuracy while minimizing occupation time. One instrument is placed over a control point (the base station) and other instruments are used as rover systems in the field. The control point system is connected to a VHF radio which broadcasts corrections signals. The rover units receive these signals and use the correction in real time to correct their location information. Since the main use for these systems is to reproducibly locate radiological survey sites, this level of accuracy is sufficient. Typically, sodium iodide detectors are located above the sites and the area monitoring

for external gamma caused largely from decay of cesium-137 ( $^{137}\text{Cs}$ ) present the underlying soils.

### **Geographic Control**

The basis for the geographic control for all the mapping efforts is the marker NOEL 2 which was placed in 1999 and mapped at that time. This was during the time that selective availability was in force for the GPS constellation causing random error to be introduced. Although the error ellipse is on the order of 90 meters, the error could be minimized with patient observation. At that time several measurements were taken and were averaged together to provide the coordinates 11° 09' 44.49962" N, 166° 53' 34.119388" E. These coordinates serve as the standard coordinates for this control point (base station) and have been used since 1999.

NOEL 2 is a piece of rebar that is embedded into a concrete piling. The general location is a small mound on the lagoon side of the main generator building. There is some concern that this monument will become a victim of the clean up activity and be scraped out and thus destroyed. One of the task assignments for this mission was to establish multiple control points in areas that will be less prone to destruction.

### **Radiological Survey Points around New Housing**

Eight houses and a piggery were geo-located during this mission. The houses were in various states of construction and the piggery was in the foundation excavation stage. The houses were located in the western portion of the village area in the vicinity of the DOE complex and the church. The piggery is located in the jungle area south of the church. Each house was assigned a number in the range 950 to 957. Radiological survey points were established three meters out from each house wall approximately in the center of that wall. The piggery has similar points except the long sides have two points at the approximate 1/3 and 2/3 distance points. The data collection technique used was to place the rover antenna over the point in question and to collect positional data for 20 readings. The readings were taken automatically 5 seconds apart. Thus the point was occupied for 100 seconds. The following diagrams show the houses and new survey points in relation to the existing grid locations. The new points are in red.

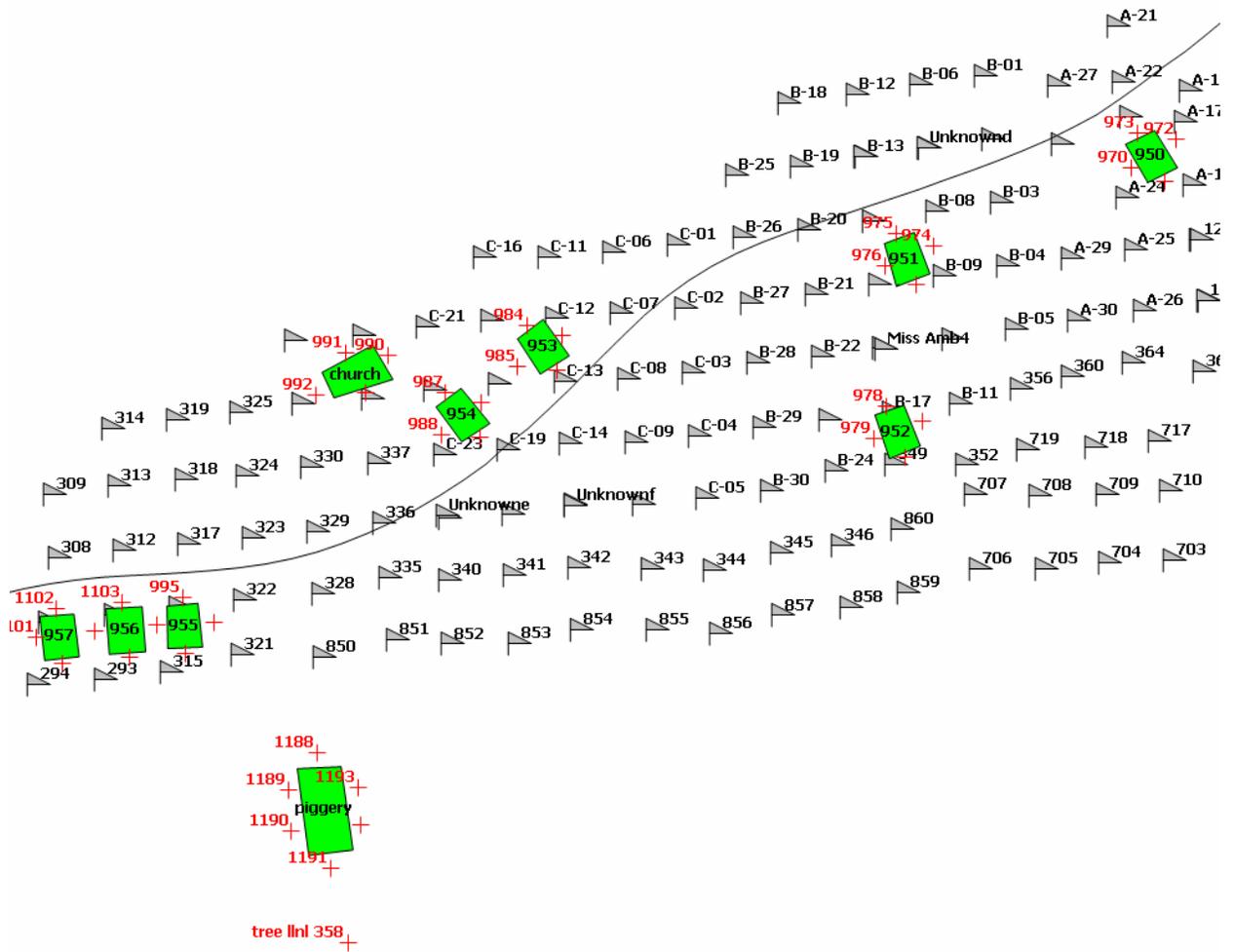
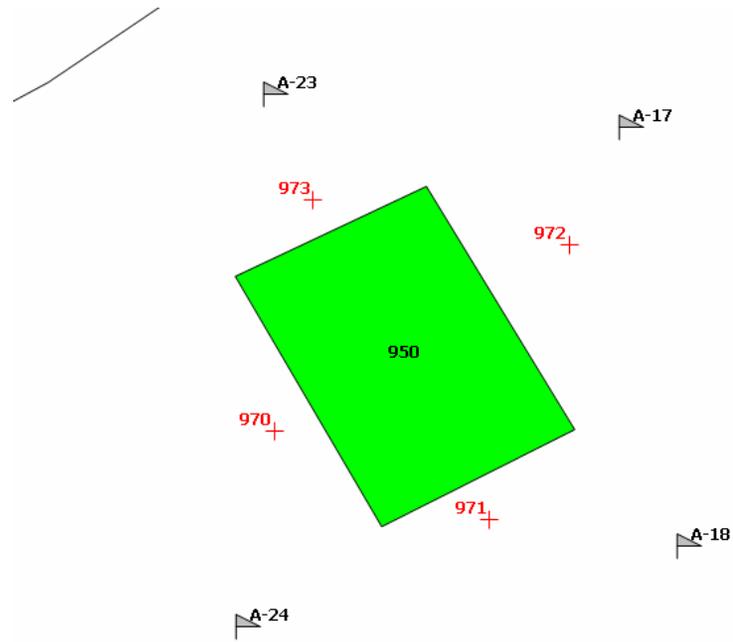


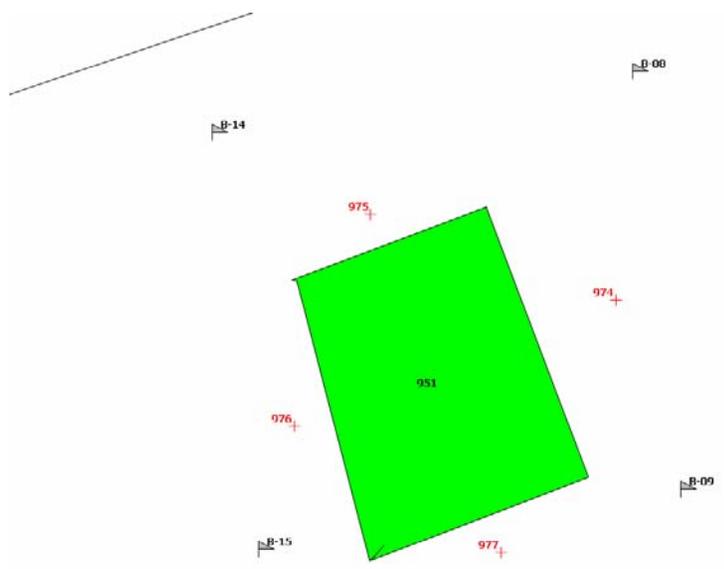
Figure 1. New Home Sites on Rongelap Island.



**Figure 2.** House 950 on Rongelap Island.

**Table 1.** Points around House 950.

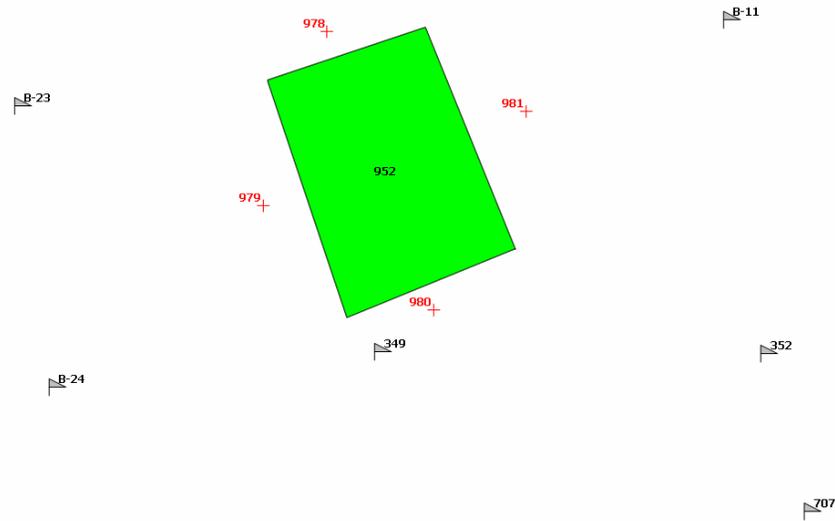
Comment	Corr_Type	GPS_Date	GPS_Time	Vert_Prec	Horz_Prec	Std_Dev	Latitude	Longitude
970	Differential	2/28/2006	05:41:16pm	48.7	29.1	0.142376	11.161442800	166.891709374
971	Differential	2/28/2006	05:46:36pm	50.7	29.9	0.132226	11.161404490	166.891802201
972	Differential	2/28/2006	05:48:56pm	49.9	29.3	0.037167	11.161522820	166.891836570
973	Differential	2/28/2006	05:51:12pm	50.2	29.3	0.173758	11.161542229	166.891726089



**Figure 3.** House 951 on Rongelap Island.

**Table 2.** Points around House 951.

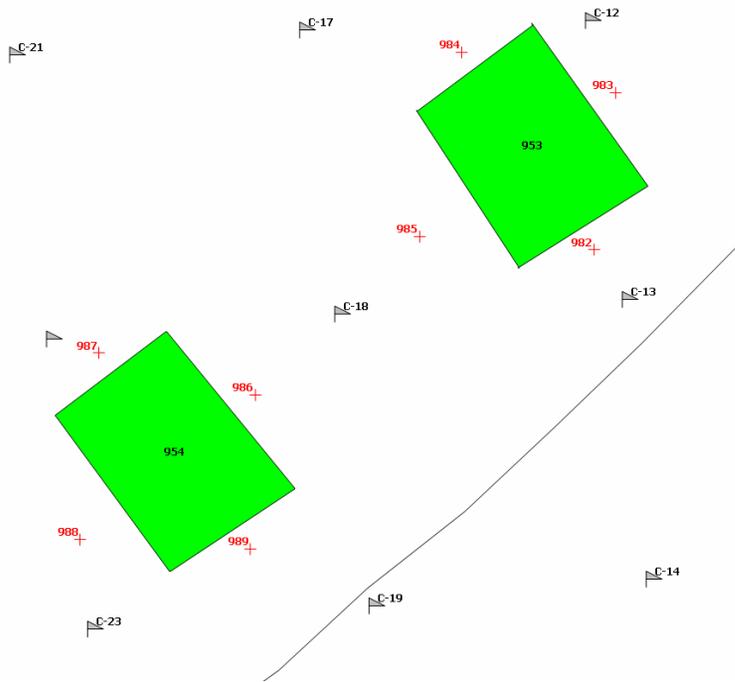
Comment	Corr_Type	GPS_Date	GPS_Time	Vert_Prec	Horz_Prec	Std_Dev	Latitude	Longitude
974	Differential	2/28/2006	05:59:10pm	51	29.3	0.094891	11.161221300	166.891154407
975	Differential	2/28/2006	06:02:06pm	59	36.2	0.317392	11.161257949	166.891048769
976	Differential	2/28/2006	06:04:27pm	45.3	25.3	0.056782	11.161167058	166.891015783
977	Differential	2/28/2006	06:07:10pm	45.3	25.1	0.081013	11.161112984	166.891105037



**Figure 4.** House 952 on Rongelap Island.

**Table 3.** Points around House 952.

Comment	Corr_Type	GPS_Date	GPS_Time	Vert_Prec	Horz_Prec	Std_Dev	Latitude	Longitude
978	Differential	2/28/2006	06:13:08pm	59.7	32.8	0.069999	11.160773051	166.891018697
979	Differential	2/28/2006	06:15:43pm	59.4	36.4	0.062129	11.160682609	166.890985739
980	Differential	2/28/2006	06:18:20pm	47.3	26.1	0.092665	11.160628533	166.891074021
981	Differential	2/28/2006	06:20:39pm	49.8	29.7	0.04975	11.160731317	166.891121922



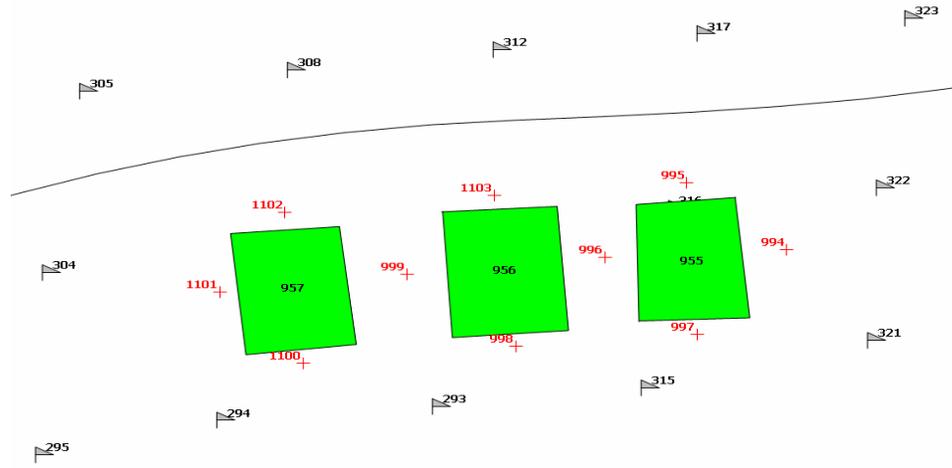
**Figure 5.** Houses 953 and 954 on Rongelap Island.

**Table 4.** Points around House 953.

Comment	Corr_Type	GPS_Date	GPS_Time	Vert_Prec	Horz_Prec	Std_Dev	Latitude	Longitude
982	Differential	3/1/2006	12:35:32pm	48.2	25.7	0.167705	11.160874094	166.890094223
983	Differential	3/1/2006	12:37:46pm	60.8	31.6	0.042273	11.160972816	166.890107773
984	Differential	3/1/2006	12:40:02pm	63.7	32	0.058936	11.160998266	166.890010567
985	Differential	3/1/2006	12:42:35pm	55.8	29.6	0.197834	11.160882292	166.889983900

**Table 5.** Points around House 954.

Comment	Corr_Type	GPS_Date	GPS_Time	Vert_Prec	Horz_Prec	Std_Dev	Latitude	Longitude
	Phase							
986	Processed	3/1/2006	12:44:55pm	92.1	38.8	0.009815	11.160782725	166.889880053
987	Differential	3/1/2006	12:47:11pm	56.7	28.9	0.082148	11.160809152	166.889781217
988	Differential	3/1/2006	12:49:30pm	65.1	32.2	0.059269	11.160691975	166.889769369
989	Differential	3/1/2006	12:51:54pm	68.7	33.2	0.146133	11.160685846	166.889876911



**Figure 6.** Houses 955, 956 and 957 on Rongelap Island.

**Table 6.** Points around House 955.

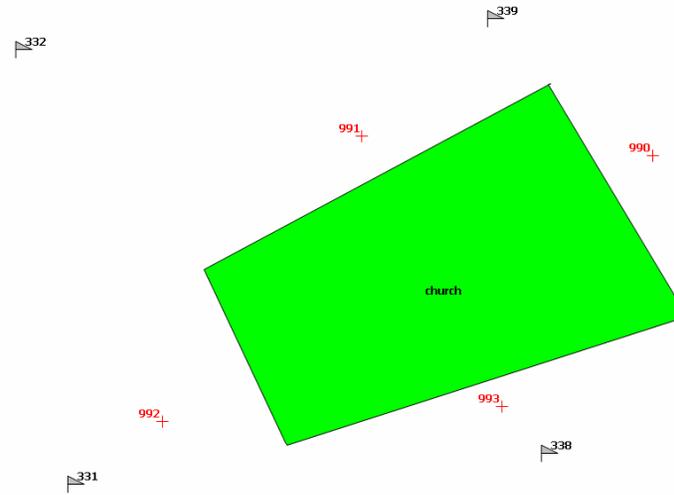
Comment	Corr_Type	GPS_Date	GPS_Time	Vert_Prec	Horz_Prec	Std_Dev	Latitude	Longitude
994	Differential	3/1/2006	01:07:13pm	49.9	25.8	0.085998	11.160163605	166.889129422
995	Differential	3/1/2006	01:10:26pm	57.3	27.1	0.063243	11.160232180	166.889041535
996	Phase Processed	3/1/2006	01:12:53pm	18.7	28.6	0.005124	11.160156420	166.888969336
997	Differential	3/1/2006	01:15:17pm	58.1	27	0.096725	11.160077226	166.889050619

**Table 7.** Points around House 956.

Comment	Corr_Type	GPS_Date	GPS_Time	Vert_Prec	Horz_Prec	Std_Dev	Latitude	Longitude
998	Differential	3/1/2006	01:17:46pm	58.4	27	0.074838	11.160065236	166.888890782
999	Differential	3/1/2006	01:20:06pm	58.5	27	0.029106	11.160138682	166.888794770
1103	Differential	3/1/2006	01:30:15pm	57.4	26.9	0.078407	11.160219088	166.888871541

**Table 8.** Points around House 957.

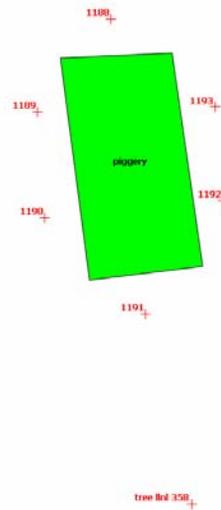
Comment	Corr_Type	GPS_Date	GPS_Time	Vert_Prec	Horz_Prec	Std_Dev	Latitude	Longitude
1100	Differential	3/1/2006	01:23:08pm	58.4	27	0.108535	11.160047834	166.888703126
1101	Differential	3/1/2006	01:25:34pm	17.9	31.3	0.001925	11.160120825	166.888629789
1102	Differential	3/1/2006	01:27:51pm	59.8	27.5	0.08515	11.160201523	166.888687107



**Figure 7.** Newly renovated Church on Rongelap Island.

**Table 9.** Points around Church.

Comment	Corr_Type	GPS_Date	GPS_Time	Vert_Prec	Horz_Prec	Std_Dev	Latitude	Longitude
990	Differential	3/1/2006	01:02:40pm	73.7	35.2	0.054611	11.160914531	166.889618805
991	Differential	3/1/2006	01:00:19pm	49.3	25.5	0.051276	11.160922784	166.889498428
992	Differential	3/1/2006	12:57:36pm	70.3	31.8	0.126756	11.160804591	166.889415806
993	Differential	3/1/2006	12:55:10pm	69.5	33.5	0.169591	11.160811016	166.889556448



**Figure 8.** Piggery site on Rongelap Island.

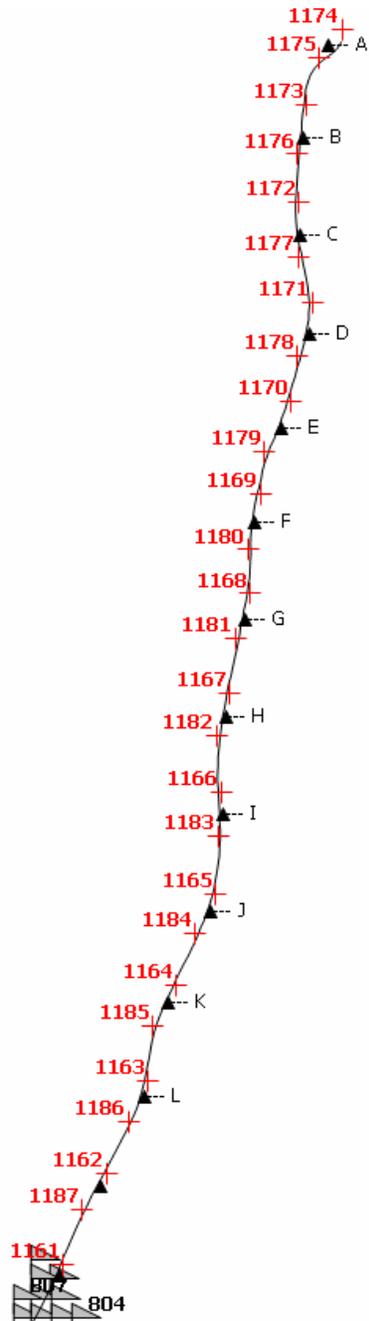
**Table 10.** Points around the piggery.

Comment	Corr_Type	GPS_Date	GPS_Time	Vert_Prec	Horz_Prec	Std_Dev	Latitude	Longitude
1188	Differential	3/2/2006	12:18:59pm	85.7	32.3	0.137331	11.159795141	166.889419421
1189	Differential	3/2/2006	12:21:53pm	72.4	29.8	0.228189	11.159693318	166.889338443
1190	Differential	3/2/2006	12:24:12pm	165.9	50.6	0	11.159576847	166.889346604
1191	Differential	3/2/2006	12:26:46pm	59.5	29.9	0.081933	11.159470900	166.889457225
1192	Differential	3/2/2006	12:29:24pm	49.2	26.8	0.090175	11.159595082	166.889542552
1193	Differential	3/2/2006	12:31:51pm	50.3	32.6	0.151821	11.159698532	166.889533838
tree Inl 358	Differential	3/2/2006	12:37:46pm	76.6	38.5	0.276028	11.159261776	166.889508275

### **Lagoon Road Radiological Survey Points**

One other aspect of this mission was to establish a network of radiological survey points along the lagoon road. The points were to be spaced approximately 100 meters apart on both sides of the road. The points were staggered such that one point was about 50 meters from the adjacent points. Due to the magnitude of this undertaking, a rover system was installed on a truck and the road was driven. The spacing was not rigorously enforced. Rather, the spacing was adjusted to provide an evenness of coverage. Since the existing sampling grid covered the road in the vicinity of the village area, only the remaining two segments were mapped. Twenty seven points were established on the upper segment and 113 on the lower. Additionally, the road was mapped with a 1 second measurement period while traveling 20 mph. This provided a measurement point approximately every 10 meters.

Be aware that in July 2003 sampling trees were identified. The tree rows were marked on the upper lagoon pavement. The black triangles indicate those points.



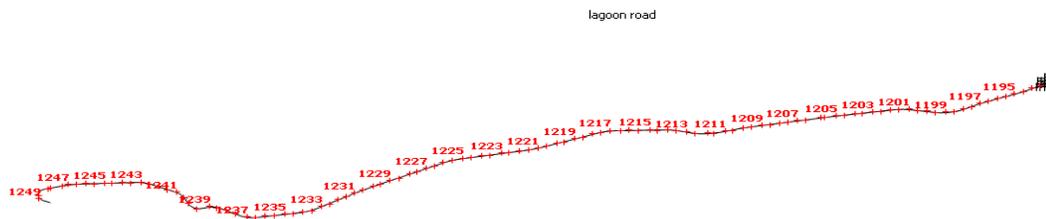
**Figure 9.** The upper lagoon road on Rongelap Island.

**Table 11. Upper Road Points.**

Comment	Corr_Type	GPS_Date	GPS_Time	Vert_Prec	Horz_Prec	Std_Dev	Latitude	Longitude
1161	Differential	3/1/2006	07:29:29pm	57.8	26.9	0.15365	11.164526225	166.893983709
1162	Differential	3/1/2006	07:32:03pm	113.4	43	0.005264	11.165363338	166.894379072
1163	Differential	3/1/2006	07:34:33pm	53.6	26.3	0.060628	11.166214122	166.894760748
1164	Phase Processed	3/1/2006	07:37:03pm	59.6	33.9	0.01143	11.167089512	166.895017835
1165	Phase Processed	3/1/2006	07:39:40pm	56.7	33.8	0.010676	11.167920978	166.895374979
1166	Differential	3/1/2006	07:41:56pm	67.3	34.2	0.140697	11.168867467	166.895426033
1167	Realtime Corrected	3/1/2006	07:44:43pm	50.2	34	0.075198	11.169769391	166.895509147
1168	Differential	3/2/2006	01:05:30pm	57.1	27.2	0.079573	11.170684806	166.895694259
1169	Differential	3/2/2006	01:08:04pm	70.9	30.2	0.166835	11.171592818	166.895785843
1170	Differential	3/2/2006	01:10:20pm	89.5	34.6	0.112765	11.172455791	166.896065984
1171	Differential	3/2/2006	01:12:33pm	70.5	29.9	0.039369	11.173353688	166.896264313
1172	Differential	3/2/2006	01:14:50pm	58.5	27.1	0.114183	11.174273298	166.896140697
1173	Differential	3/2/2006	01:16:57pm	58.6	27.1	0.093561	11.175179263	166.896212325
1174	Differential	3/2/2006	01:19:17pm	58.5	27	0.11191	11.175864164	166.896538214
1175	Differential	3/2/2006	01:21:35pm	58.3	27	0.057725	11.175602240	166.896326255
1176	Differential	3/2/2006	01:23:45pm	58	29.4	0.150453	11.174719119	166.896127158
1177	Differential	3/2/2006	01:26:14pm	76.6	31.7	0.212453	11.173777953	166.896136749
1178	Differential	3/2/2006	01:28:35pm	79.4	31.5	0.102904	11.172865588	166.896128490
1179	Differential	3/2/2006	01:30:47pm	72.7	35.2	0.165304	11.171982025	166.895822485
1180	Differential	3/2/2006	01:33:35pm	56.2	29.4	0.170758	11.171087695	166.895672351
1181	Differential	3/2/2006	01:36:06pm	59.4	31.4	0.321916	11.170271412	166.895555125
1182	Differential	3/2/2006	01:38:17pm	69.2	30.1	0.068086	11.169376444	166.895387636
1183	Differential	3/2/2006	01:40:31pm	49	24.7	0.121102	11.168463964	166.895396074
1184	Differential	3/2/2006	01:42:40pm	56.5	26.6	0.114482	11.167558329	166.895193129
1185	Differential	3/2/2006	01:44:48pm	53.3	25.8	0.156907	11.166715757	166.894804087
1186	Differential	3/2/2006	01:47:03pm	63.5	30.5	0.149276	11.165838436	166.894577419
1187	Differential	3/2/2006	01:49:25pm	59.8	27.4	0.090774	11.165030814	166.894153720

**Table 12.** 2003 Sampling Tree Row Markers.

Comment	Longitude	Latitude
A	166.896407410	11.175726422
B	166.896184917	11.174867934
C	166.896156260	11.173973486
D	166.896233847	11.173073675
E	166.895973854	11.172210410
F	166.895736742	11.171340961
G	166.895644331	11.170440505
H	166.895468687	11.169555433
I	166.895446330	11.168655577
J	166.895329112	11.167760720
K	166.894942371	11.166935079
L	166.894725161	11.166061367
M	166.894322001	11.165250814
N	166.893949079	11.164426860
O	166.893516926	11.163635865



**Figure 10.** The lower lagoon road on Rongelap Island.

**Table 13. Lower Road Points.**

Comment	Corr_Type	GPS_Date	GPS_Time	Vert_Prec	Horz_Prec	Std_Dev	Latitude	Longitude
1104	Differential	3/1/2006	03:27:49pm	64.3	26.1	0.07799	11.153198049	166.837578423
1105	Differential	3/1/2006	03:32:29pm	98.6	31.7	0.127015	11.153600414	166.838072949
1106	Differential	3/1/2006	03:35:59pm	65.4	26.4	0.104093	11.153751743	166.838770604
1107	Differential	3/1/2006	03:38:20pm	80.2	29.4	0.047074	11.153863413	166.839497499
1108	Differential	3/1/2006	03:41:02pm	79.5	29.5	0.112764	11.153898758	166.840390998
1109	Differential	3/1/2006	03:45:45pm	95	30	0.146206	11.153932985	166.841249142
1110	Differential	3/1/2006	05:12:39pm	65.7	34.7	0.09674	11.153967509	166.842220975
1111	Differential	3/1/2006	05:15:04pm	168.7	36.2	0.009789	11.153878967	166.843166894
1112	Phase Processed	3/1/2006	05:17:30pm	168.9	36.8	0.008988	11.153534462	166.844052242
1113	Differential	3/1/2006	05:19:50pm	166.8	37.1	0.009101	11.153077840	166.844867861
1114	Phase Processed	3/1/2006	05:22:10pm	132.7	27.2	0.013917	11.152357551	166.845517718
1115	Phase Processed	3/1/2006	05:25:37pm	144.4	27.7	0.009936	11.152423239	166.846560097
1116	Differential	3/1/2006	05:28:04pm	225.8	33.9	0.013821	11.152016440	166.847468160
1117	Differential	3/1/2006	05:30:59pm	47.6	29.2	0.137494	11.151784041	166.848503797
1118	Phase Processed	3/1/2006	05:33:18pm	23.3	18.6	0.006318	11.151915058	166.849437562
1119	Phase Processed	3/1/2006	05:35:33pm	22.7	18.8	0.00449	11.152045860	166.850378354
1120	Phase Processed	3/1/2006	05:37:51pm	22.1	19	0.006144	11.152245250	166.851336177
1121	Phase Processed	3/1/2006	05:40:05pm	21.6	19.2	0.006741	11.152659260	166.852215660
1122	Phase Processed	3/1/2006	05:42:12pm	21.5	19.8	0.008976	11.153087790	166.853076410
1123	Phase Processed	3/1/2006	05:44:25pm	19.7	19.7	0.003786	11.153501399	166.853921613
1124	Phase Processed	3/1/2006	05:46:32pm	20	19.8	0.006681	11.153883752	166.854819896
1125	Phase Processed	3/1/2006	05:48:42pm	20.1	20	0.004154	11.154257548	166.855718680
1126	Phase Processed	3/1/2006	05:50:52pm	20.1	20.2	0.004206	11.154638609	166.856630266
1127	Phase Processed	3/1/2006	05:53:15pm	20	20.4	0.00462	11.155006840	166.857515894
1128	Phase Processed	3/1/2006	05:55:24pm	20.3	20.6	0.006117	11.155353706	166.858440635
1129	Differential	3/1/2006	05:57:40pm	45.4	26.8	0.008927	11.155525198	166.859384427
1130	Phase Processed	3/1/2006	05:59:53pm	51.7	27.9	0.00906	11.155678338	166.860329162

**Table 13.** Continued

Comment	Corr_Type	GPS_Date	GPS_Time	Vert_Prec	Horz_Prec	Std_Dev	Latitude	Longitude
1131	Phase Processed	3/1/2006	06:02:20pm	58.4	28.9	0.006165	11.155834618	166.861283004
1132	Differential	3/1/2006	06:04:39pm	51.2	29.4	0.13393	11.155993580	166.862253210
1133	Phase Processed	3/1/2006	06:07:14pm	73.4	27.4	0.008373	11.156235298	166.863165243
1134	Differential	3/1/2006	06:09:40pm	62.6	27.1	0.01249	11.156520345	166.864073515
1135	Phase Processed	3/1/2006	06:11:58pm	77.5	28.2	0.008788	11.156815028	166.865002126
1136	Differential	3/1/2006	06:14:17pm	46.1	25.2	0.094983	11.157092881	166.865907890
1137	Differential	3/1/2006	06:16:43pm	59.2	36.3	0.160513	11.157198936	166.866870180
1138	Differential	3/1/2006	06:19:18pm	50.3	27	0.092205	11.157212364	166.867783436
1139	Differential	3/1/2006	06:21:40pm	47.8	26	0.141812	11.157232139	166.868733374
1140	Differential	3/1/2006	06:24:48pm	49.5	28.4	0.125863	11.157207778	166.869689418
1141	Differential	3/1/2006	06:28:41pm	44.5	28	0.153646	11.157021687	166.870628543
1142	Phase Processed	3/1/2006	06:30:59pm	33.7	28	0.008036	11.157046346	166.871571520
1143	Differential	3/1/2006	06:33:30pm	52.3	29	0.009929	11.157235495	166.872518592
1144	Differential	3/1/2006	06:35:57pm	50.5	27.2	0.279935	11.157427371	166.873458560
1145	Differential	3/1/2006	06:38:47pm	226.7	35.9	0	11.157576900	166.874402743
1146	Phase Processed	3/1/2006	06:41:12pm	129.5	32.5	0.030673	11.157723940	166.875320901
1147	Differential	3/1/2006	06:43:36pm	80.9	31	0.03266	11.157869001	166.876236330
1148	Phase Processed	3/1/2006	06:45:57pm	60.1	30.7	0.016926	11.158019038	166.877183974
1149	Realtime Corrected	3/1/2006	06:48:19pm	89	40.8	0.142125	11.158160446	166.878164461
1150	Realtime Corrected	3/1/2006	06:50:40pm	89.7	40.8	0.097344	11.158283741	166.879063660
1151	Realtime Corrected	3/1/2006	06:53:01pm	92.6	40.7	0.092206	11.158407583	166.879981272
1152	Realtime Corrected	3/1/2006	06:55:21pm	92.6	40.7	0.060727	11.158519165	166.880902423
1153	Realtime Corrected	3/1/2006	06:57:48pm	96.7	40.1	0.097443	11.158451292	166.881821438
1154	Realtime Corrected	3/1/2006	07:00:16pm	96.6	39.8	0.089382	11.158332449	166.882727018
1155	Realtime Corrected	3/1/2006	07:02:31pm	96.6	39.3	0.162951	11.158376473	166.883671787
1156	Differential	3/1/2006	07:04:45pm	82	32.5	0.082181	11.158687441	166.884556639
1157	Differential	3/1/2006	07:07:02pm	79.9	32	0.034293	11.159024953	166.885423198
1158	Realtime Corrected	3/1/2006	07:09:47pm	92.3	37.7	0.093865	11.159325670	166.886289601
1159	Realtime Corrected	3/1/2006	07:12:19pm	86.5	35.5	0.071933	11.159632715	166.887169475

**Table 13.** Continued

Comment	Corr_Type	GPS_Date	GPS_Time	Vert_Prec	Horz_Prec	Std_Dev	Latitude	Longitude
1160	Realtime Corrected	3/1/2006	07:14:55pm	87.8	36	0.09566	11.159997512	166.888009110
1194	Differential	3/2/2006	01:59:34pm	53.8	27.1	0.22203	11.159851022	166.887603864
1195	Differential	3/2/2006	02:02:56pm	51.8	26.2	0.088351	11.159502057	166.886723954
1196	Differential	3/2/2006	02:05:41pm	76.3	37.1	0.427265	11.159229235	166.885873301
1197	Differential	3/2/2006	02:09:56pm	79.1	36.3	0.240845	11.158929906	166.885000131
1198	Differential	3/2/2006	02:13:01pm	71.3	32.7	0.121535	11.158563377	166.884164074
1199	Differential	3/2/2006	02:15:35pm	69.3	31.4	0.054984	11.158364447	166.883263297
1200	Differential	3/2/2006	02:20:18pm	66	30.7	0.093816	11.158430939	166.882339714
1201	Differential	3/2/2006	02:23:03pm	64.3	30.3	0.051152	11.158550804	166.881418629
1202	Differential	3/2/2006	02:25:59pm	62.6	29.9	0.113933	11.158523541	166.880489822
1203	Differential	3/2/2006	02:29:15pm	61	29.6	0.05627	11.158396379	166.879581263
1204	Differential	3/2/2006	02:31:40pm	202.9	43.3	0.007628	11.158277417	166.878682428
1205	Phase Processed	3/2/2006	02:34:14pm	201.5	44.1	0.023128	11.158152784	166.877768428
1206	Differential	3/2/2006	02:44:30pm	113	47.5	0.089733	11.158037246	166.876957609
1207	Differential	3/2/2006	02:49:05pm	117.5	47.7	0.076046	11.157856089	166.875812502
1208	Differential	3/2/2006	02:52:09pm	120.1	47.6	0.102509	11.157711131	166.874901723
1209	Differential	3/2/2006	02:55:12pm	122.2	47.3	0.102715	11.157560958	166.873990761
1210	Differential	3/2/2006	02:57:59pm	123.8	46.6	0.138352	11.157410966	166.873063968
1211	Differential	3/2/2006	03:02:30pm	124.2	45.8	0.1363	11.157210269	166.872173828
1212	Differential	3/2/2006	03:10:49pm	120.9	43.1	0.109295	11.157065496	166.871289084
1213	Differential	3/2/2006	03:15:22pm	116.8	41.5	0.08062	11.157160011	166.870193510
1214	Differential	3/2/2006	03:19:34pm	73.3	35.4	0.121424	11.157291760	166.869293545
1215	Differential	3/2/2006	03:26:43pm	76.4	35.7	0.11373	11.157277076	166.868374868
1216	Differential	3/2/2006	03:30:56pm	66	30.7	0.187319	11.157250909	166.867294733
1217	Differential	3/2/2006	03:34:31pm	90.7	36.9	0.27989	11.157228073	166.866357739
1218	Differential	3/2/2006	05:59:30pm	77.6	37.5	0.198116	11.157006396	166.865451843
1219	Differential	3/2/2006	06:02:12pm	57.1	26.1	0.078983	11.156717597	166.864556324

**Table 13.** Continued

Comment	Corr_Type	GPS_Date	GPS_Time	Vert_Prec	Horz_Prec	Std_Dev	Latitude	Longitude
1220	Differential	3/2/2006	06:05:07pm	247.9	38	0.024071	11.156441813	166.863676488
1221	Differential	3/2/2006	06:08:34pm	55.4	25.9	0.098885	11.156145409	166.862730755
1222	Differential	3/2/2006	06:11:12pm	55.8	42.4	0.094971	11.155970045	166.861816082
1223	Phase Processed	3/2/2006	06:14:01pm	248.8	45.5	0.034408	11.155821857	166.860906274
1224	Differential	3/2/2006	06:16:51pm	53.9	34.1	0.308579	11.155655999	166.859872807
1225	Differential	3/2/2006	06:19:28pm	63	29.4	0.12486	11.155504458	166.858957738
1226	Phase Processed	3/2/2006	06:22:05pm	51.1	22.6	0.0068	11.155245014	166.857967320
1227	Phase Processed	3/2/2006	06:24:39pm	50.9	22.9	0.005154	11.154890967	166.857110263
1228	Phase Processed	3/2/2006	06:27:13pm	52.6	23.2	0.005414	11.154532597	166.856247644
1229	Phase Processed	3/2/2006	06:29:49pm	56.1	23.6	0.008009	11.154125795	166.855274080
1230	Phase Processed	3/2/2006	06:32:37pm	58	23.9	0.010445	11.153775671	166.854426101
1231	Differential	3/2/2006	06:35:18pm	108.7	41	0.118332	11.153343804	166.853485283
1232	Phase Processed	3/2/2006	06:37:59pm	79	32	0.009013	11.152923003	166.852646592
1233	Phase Processed	3/2/2006	06:40:39pm	80.4	32.8	0.00791	11.152517790	166.851833674
1234	Phase Processed	3/2/2006	06:43:34pm	78.4	33	0.006347	11.152167077	166.850894148
1235	Phase Processed	3/2/2006	06:46:14pm	76.8	34.3	0.007537	11.152037524	166.849997114
1236	Differential	3/2/2006	06:48:59pm	118.1	39.9	0.062179	11.151901820	166.848994799
1237	Differential	3/2/2006	06:51:35pm	113.4	39.6	0.097073	11.151848483	166.848077875
1238	Differential	3/2/2006	06:54:09pm	94.2	36.7	0.043987	11.152269737	166.847049536
1239	Differential	3/2/2006	06:56:55pm	95.6	37.5	0.313185	11.152491020	166.846168873
1240	Differential	3/2/2006	07:00:21pm	58.4	47.7	0.113516	11.152714821	166.845098883
1241	Differential	3/2/2006	07:03:27pm	74.1	33.7	0.007982	11.153405814	166.844514382
1242	Phase Processed	3/2/2006	07:06:24pm	80	34	0.006141	11.153749180	166.843641899
1243	Differential	3/2/2006	07:09:19pm	75.5	32.1	0.049465	11.154014213	166.842753865

**Table 13.** Continued

<b>Comment</b>	<b>Corr_Type</b>	<b>GPS_Date</b>	<b>GPS_Time</b>	<b>Vert_Prec</b>	<b>Horz_Prec</b>	<b>Std_Dev</b>	<b>Latitude</b>	<b>Longitude</b>
1244	Differential	3/2/2006	07:11:54pm	72.6	31.6	0.118678	11.153999088	166.841825593
1245	Differential	3/2/2006	07:14:43pm	68.9	30.9	0.123234	11.153970223	166.840911056
1246	Differential	3/2/2006	07:17:31pm	65.9	30.4	0.122593	11.153936140	166.839988935
1247	Differential	3/2/2006	07:20:44pm	62.6	29.9	0.081323	11.153859943	166.839061671
1248	Differential	3/2/2006	07:23:10pm	60.5	31.4	0.041173	11.153669988	166.838177825
1249	Differential	3/2/2006	07:26:18pm	58	29.2	0.089927	11.152974025	166.837615978

### **Existing Radiological Survey Points**

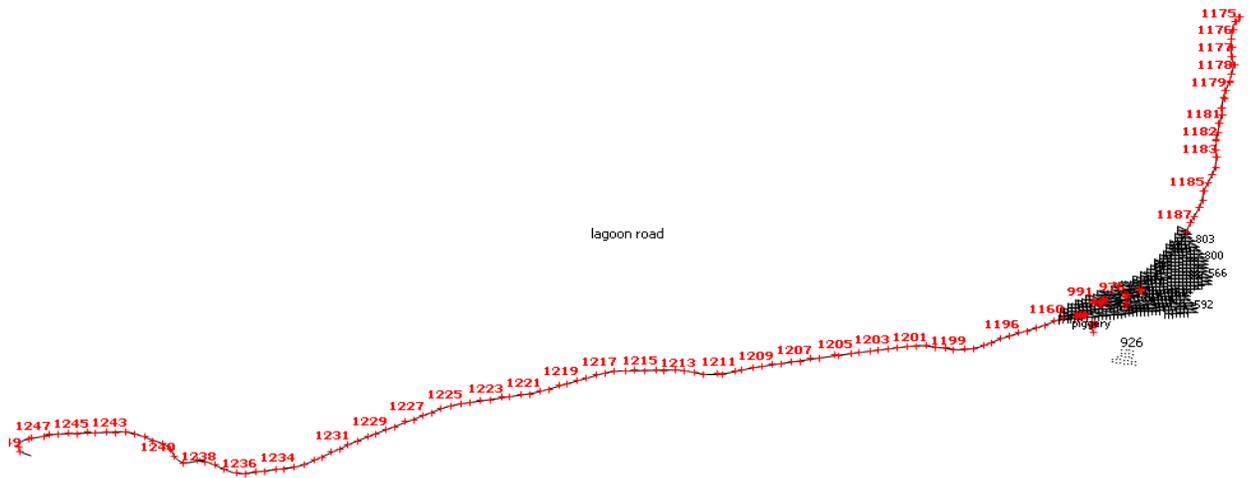
Three existing grid points were recovered. These points were originally mapped but no data was taken. Two of the points, 509 and 526, are located in the corporation yard area of the village. During previous trips, this area was the site of machinery and piles of crushed coral. One point is located on an abandoned concrete footing. The other was in the area of a material pile. Point 720 is in the area south of the DOE trailers. It was determined to be co-located with point 719.

### **New Geographic Control Points**

The possibility of the future destruction of the primary control monument, NOEL 2, makes it prudent to establish additional points that can be used as geographic control. Three sites were selected on the basis of open sky availability, being in an area that would be less likely to be disturbed and have sufficient space to set up two tripods and related base station equipment. The first site is in the lagoon road directly in front of the DOE/LLNL whole body counting building. The second site is on the pier. The third site is in the grass area by the airport apron. Unfortunately, time on island was not sufficient to make the required observations to get coordinates with sufficient precision.

### **Acknowledgment**

We are indebted to the Marshall Islands logistics support group of Bechtel Nevada who provided all the necessary things that made the project go smoothly. Joseph F. Strzelewicz was especially helpful with the field portion of the mapping project. Without his help, the field mapping would have taken considerably longer. Staff from Pacific International Incorporated (PII) also provided assistance in placement of the new control points.



**Figure 11.** Outline of the total mapping project on Rongelap Island (Feb.-March 2006)



# Appendix I

## **GPS File Archive**

**Table 14.** Files taken during this mission.

<b>Date</b>	<b>Time</b>	<b>Size</b>	<b>Name</b>
2/28/2006	09:33p	88,303	B6030105.ssf
2/28/2006	09:33p	48,503	B6030109.ssf
3/1/2006	04:32p	5,479	B6030207.ssf
3/1/2006	04:32p	39,915	B6030210.ssf
3/1/2006	09:05p	4,641	B6030212.ssf
3/1/2006	09:05p	79,225	B6030215.ssf
3/2/2006	04:13p	12,165	B6030307.ssf
3/2/2006	04:13p	9,377	B6030309.ssf
3/2/2006	04:13p	66,629	B6030310.ssf
3/2/2006	08:08p	98,023	B6030313.ssf
2/28/2006	09:34p	43,196	R030107A.cor
2/28/2006	09:34p	11,444	R030107A.LOG
2/28/2006	06:36p	12,227	R030107A.ssf
2/28/2006	09:34p	18,829	R030109A.cor
2/28/2006	09:34p	6,868	R030109A.LOG
2/28/2006	07:41p	71,868	R030109A.ssf
3/1/2006	04:33p	49,947	R030208A.cor
3/1/2006	04:33p	11,053	R030208A.LOG
3/1/2006	01:41p	89,012	R030208A.ssf
3/1/2006	04:33p	27,124	R030211A.cor
3/1/2006	04:33p	10,471	R030211A.LOG
3/1/2006	04:02p	00,464	R030211A.ssf
3/1/2006	09:06p	82,406	R030212A.cor
3/1/2006	09:06p	11,902	R030212A.LOG
3/1/2006	09:02p	4,648	R030212A.ssf
3/1/2006	09:06p	47,520	R030214A.cor
3/1/2006	09:06p	10,630	R030214A.LOG
3/1/2006	09:02p	72,026	R030214A.ssf
3/1/2006	09:06p	80,808	R030215A.cor
3/1/2006	09:06p	8,775	R030215A.LOG
3/1/2006	09:02p	14,475	R030215A.ssf
3/2/2006	04:14p	30,107	R030308A.cor
3/2/2006	04:14p	5,928	R030308A.LOG
3/2/2006	04:07p	21,996	R030308A.ssf
3/2/2006	04:14p	56,379	R030309A.cor
3/2/2006	04:14p	9,406	R030309A.LOG
3/2/2006	04:07p	63,524	R030309A.ssf
3/2/2006	04:14p	62,887	R030309B.cor
3/2/2006	04:14p	17,343	R030309B.LOG
3/2/2006	04:07p	30,366	R030309B.ssf

**Table 14. Continued**

<b>Date</b>	<b>Time</b>	<b>Size</b>	<b>Name</b>
3/2/2006	08:08p	87,999	R030313A.cor
3/2/2006	08:08p	11,105	R030313A.LOG
3/2/2006	08:07p	33,971	R030313A.ssf
3/2/2006	08:07p	8,776	R030315A.ssf
3/2/2006	08:09p	88,488	R030315B.cor
3/2/2006	08:09p	5,436	R030315B.LOG
3/2/2006	08:07p	69,356	R030315B.ssf



# Appendix II

## **GIS Metadata Summary Information**

## GIS Metadata Information

### Identification\_Information

#### Citation

##### Citation\_Information

Originator: James L. Brunk

Publication\_Date: January 2007

Title: Rongelap Island Geographical Information System (GIS) Sample Site Mapping

Geospatial\_Data\_Presentation\_Form: Tables and diagrams

##### Publication\_Information

Publication\_Place: Livermore, California

Publisher: Lawrence Livermore Laboratory

Other\_Citation\_Details: UCRL-MI-231660

Online\_Linkage:

#### Description

*Abstract:* During March 2006, an effort was made to map new radiological survey points on the Island of Rongelap (Rongelap Atoll) in the northern Marshall Islands. New points were placed on both sides of the lagoon road. Several grid points were set in locations that were inaccessible during previous surveys. Newly built houses and a piggery were geolocated and gamma survey points adjacent to them were created. Five prospective control points were reconnoitered.

*Purpose:* These data provide positional information for radiological survey data

#### Time\_Period\_of\_Content

##### Time\_Period\_Information

##### Range\_of\_Dates/Times

Beginning\_Date: 1 March 2006

Ending\_Date: 4 March 2006

Currentness\_Reference:

#### Status

Progress: Completed

Maintenance\_and\_Update\_Frequency: none

#### Spatial\_Domain

##### Bounding\_Coordinates

West\_Bounding\_Coordinate: 166.8376 °E

East\_Bounding\_Coordinate: 166.8965 °E

North\_Bounding\_Coordinate: 11.1758 °N

South\_Bounding\_Coordinate: 11.1529 °N

#### Keywords

##### Theme

Theme\_Keyword: GPS

Theme\_Keyword: Radiological

##### Place

Place\_Keyword: Rongelap Atoll

#### Access\_Constraints:

Use\_Constraints: Information is provided as is.

#### Point\_of\_Contact

##### Contact\_Information

Contact\_Person\_Primary

Contact\_Person: James L. Brunk

Contact\_Organization: Lawrence Livermore National Laboratory

Contact\_Address

Address\_Type:

Address: P.O. Box 808 L-231

City: Livermore

State\_or\_Province: CA

Postal\_Code: 94550

Country: USA

Contact\_Voice\_Telephone: 925-422-6631

Contact\_Facsimile\_Telephone: 925-422-3160

Contact\_Electronic\_Mail\_Address: brunk1@llnl.gov

Hours\_of\_Service: 8 am – 4 pm

Spatial\_Reference\_Information

Horizontal\_Coordinate\_System\_Definition

Planar

Grid\_Coordinate\_System

Grid\_Coordinate\_System\_Name: Latitude / Longitude

Geodetic\_Model

Horizontal\_Datum\_Name: WGS84

Ellipsoid\_Name: WGS84

Semi-major\_Axis: 6378137 m

Denominator\_of\_Flattening\_Ratio: 298.257223563 (derived from the value of the normalized second degree zonal harmonic coefficient of the gravitational field:  $-484.16685 \times 10^{-6}$ )

Metadata\_Reference\_Information

Metadata\_Date: April 2006

Metadata\_Contact

Contact\_Information

Contact\_Organization\_Primary

Contact\_Organization: Lawrence Livermore National Laboratory

Contact\_Position:

Contact\_Address

Address\_Type:

Address: P.O. Box 808

City: Livermore

State\_or\_Province: California

Postal\_Code: 94550

Country: USA



University of California  
Lawrence Livermore National Laboratory  
Technical Information Department  
Livermore, CA 94551

