

MAINE YANKEE
FINAL STATUS SURVEY RELEASE RECORD
FR-0400 FOREBAY
SURVEY UNIT 2

| | | |
|--------------|--|--------------------------|
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**MAINE YANKEE
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FR-0400 FOREBAY
SURVEY UNIT 2**

A. SURVEY UNIT DESCRIPTION

Survey Unit 2 is located within Survey Area FR-0400, the Forebay. The Forebay is located south of the site radiologically Restricted Area at coordinates 407,250 N and 623,700 E (see map FR0400-SITE, Attachment 1). The Forebay is a large, rock-lined basin in which condenser cooling water collected prior to its release through the diffuser system out to the ocean. During plant operation, the Forebay/Diffuser system was the licensed discharge path for liquid, radiological effluent. After plant shutdown, stop logs were set in place at the Forebay end of the diffuser to isolate the Forebay in order to prevent the release of Forebay sediment into the river during remediation activities.

Two earthen dikes make up the north-south running walls of the Forebay with concrete walls at the extreme north and south ends to support the circulating water and diffuser pipes. The dike walls form a V at the southern end of the Forebay (adjacent to Foxbird Island). The diffuser discharge pipes originate at the notch of the V. A concrete dam, or weir, runs in the east west direction at the northern end of the Forebay and creates a small, water-filled area called the sealpit. The sealpit maintained a water seal over the circulating water pipes to prevent loss of flow with tidal fluctuations.

Survey Unit 2 consists of the upper walls of the sealpit above an elevation of 4.5 feet. The sealpit walls consist of exposed ledge, gravel and native soil matrix materials. The upper walls were normally above the water level of the sealpit. The Survey Unit has a surface area of approximately 1,475 m².

B. SURVEY UNIT DESIGN INFORMATION

The Forebay received the liquid radioactive discharges from the plant. It was known to have been contaminated to levels in excess of the release limits and extensive remediation activities including underwater dredging, underwater vacuuming, and dry surface vacuuming were performed. Given the high probability of residual contamination, the Forebay was classified as Class 1.

Revision 3 of the Maine Yankee License Termination Plan (LTP) ¹ states that the Forebay dose from residual radioactivity "is so insignificant and the probability so low that an individual would be able to successfully place a viable well within the Forebay, survey measurements of the Forebay surfaces including rip-rap will be limited". As a result, the survey design for the Forebay is a reasonable approach to demonstrate compliance with the release criteria while not necessarily meeting all of the requirements for a "MARSSIM" survey.

¹ LTP, Revision 3 refers to the LTP submitted in October 2002 (Reference 1) as amended by the MY's addenda of November 2002 (Reference 2). LTP, Revision 3 was approved by the NRC in February 2003 (Reference 3).

The survey unit design parameters are shown in Table 1. The values shown in this Table reflect those used for the design and implementation of the survey. Changes to several key parameters (i.e., DCGL and AF) occurred after the survey was complete. These changes were used to evaluate the data, are discussed in Section H, and shown in Table 2-2.

Given a relative shift of 1.6, a minimum number of 17 direct samples were required for Survey Unit 2. The survey design was based on 20 samples. Nineteen points actually fell within the survey unit using a random start point and a square grid to determine sample locations. These locations are presented on survey map FR0400-02a and FR0400-02b (Attachment 2). Direct measurements consisting of soil samples collected from required locations were analyzed with laboratory gamma spectroscopy instrumentation.

In accordance with the LTP, scans covering 100% of the 1475 m² area were required for this Class 1 survey unit. This was accomplished by use of an ISOCS *in situ* gamma spectroscopy system positioned 4.3 m from the surface to obtain an approximate 58 m² field of view to a depth of 15 centimeters for each scan. A total of 52 measurements, located on a 6 m x 6 m grid pattern, were designed to achieve the 100% scan coverage. Each grid was scanned with detection limits well below the design DCGL_{EMC}. The investigation level was set equal to the design DCGL_{EMC}. To avoid the safety hazard to personnel posed by the steep walls around the sealpit, a crane was used to lower the ISOCS into position. The survey instruments used, their MDC values, and investigation levels are provided in Attachment 2.

TABLE 1
SURVEY UNIT DESIGN PARAMETERS

| Survey Unit | Design Criteria | Basis |
|--|----------------------|--|
| Area | 1,475 m ² | |
| Number of Direct Measurements Required | 17 (20 used) | Based on an LBGR of 3.5 pCi/g, sigma ² of 2.18 pCi/g, and a relative shift of 1.6. Type I = Type II = 0.05 |
| Sample Area | 73.8 m ² | 1,475 / 20 samples |
| Sample Grid Spacing | 8.55 m | (73.8) ^{1/2} |
| Area Factor (AF) | 3.48 | Forebay technical basis document (Reference 4) |
| Scan Survey Area | 1475 m ² | ~ 100% accessible areas |
| Background | N/A | <i>In situ</i> gamma spec used |
| Scan Investigation Level | 24.4 pCi/g Co-60 | ~ DCGL _{EMC} |
| DCGL | 7 pCi/g Co-60 | Forebay technical basis document (Reference 4) |
| Design DCGL _{EMC} | 24.4 pCi/g Co-60 | Area Factor x DCGL |

² Sigma was determined using post remediation survey results.

C. SURVEY RESULTS

Nineteen measurements were required by the survey instruction. Eighteen were actually obtained due to the inaccessible location of sample R004. The direct measurement data are presented in Table 2 below. All direct measurements were below the DCGL.

The survey was designed for 52 ISOCS measurements to provide 100% scan coverage. Five of the measurement locations (R001 through R005) were inaccessible due to the proximity of the waterline along the western boundary. Forty-seven measurements were made with all results below the investigation level. Therefore, no investigations were required.

TABLE 2
DIRECT MEASUREMENTS

| Sample Number | Cs-137 (pCi/g) | Co-60 (pCi/g) | Utilized Values ³ |
|---------------------------|----------------------------|----------------------------|------------------------------|
| FR0400-02-1-R001RS | < 2.76E-02 | < 3.61E-02 | 9.51E-04 |
| FR0400-02-1-R002RS | < 3.39E-02 | < 3.21E-02 | 9.13E-04 |
| FR0400-02-1-R003RS | < 2.77E-02 | < 2.81E-02 | 7.85E-04 |
| FR0400-02-1-R004RS | Not Accessible | Not Accessible | N/A |
| FR0400-02-1-R005RS | < 5.85E-02 | < 6.88E-02 | 1.85E-03 |
| FR0400-02-1-R006RS | < 2.98E-02 | < 2.94E-02 | 8.27E-04 |
| FR0400-02-1-R007RS | < 2.83E-02 | < 2.81E-02 | 7.89E-04 |
| FR0400-02-1-R008RS | 6.40E-02 + 1.01E-02 | 1.13E-01 ± 1.38E-02 | 2.82E-03 |
| FR0400-02-1-R009SS | < 6.77E-02 | < 9.02E-02 | 2.37E-03 |
| FR0400-02-1-R010SS | 3.70E-01 + 3.50E-02 | < 4.86E-02 | 3.68E-03 |
| FR0400-02-1-R011SS | 2.55E-01 + 2.44E-02 | < 3.69E-02 | 2.60E-03 |
| FR0400-02-1-R012RS | < 2.66E-02 | < 3.02E-02 | 8.20E-04 |
| FR0400-02-1-R013SS | 3.38E-01 + 3.86E-02 | 4.64E-01 ± 3.45E-02 | 1.21E-02 |
| FR0400-02-1-R014RS | < 2.68E-02 | < 3.41E-02 | 9.03E-04 |
| FR0400-02-1-R015RS | < 5.18E-02 | < 5.05E-02 | 1.42E-03 |
| FR0400-02-1-R016RS | < 3.84E-02 | < 4.10E-02 | 1.13E-03 |
| FR0400-02-1-R017SS | 2.61E-01 + 7.44E-02 | < 1.37E-01 | 4.73E-03 |
| FR0400-02-1-R018RS | < 2.53E-02 | < 2.49E-02 | 7.01E-04 |
| FR0400-02-1-R019RS | < 2.76E-02 | < 2.81E-02 | 7.84E-04 |
| Mean | 9.77E-02 | 7.34E-02 | 2.23E-03 |
| Median | 3.62E-02 | 3.65E-02 | 1.04E-03 |
| Standard Deviation | 1.18E-01 | 1.03E-01 | 2.72E-03 |
| Range | 2.53E-02 – 3.70E-01 | 2.49E-02 – 4.64E-01 | 7.01E-04 – 1.21E-02 |

“<” indicates MDA value. Bold indicates positive detection value.

³ These values were adjusted to account for the contamination depth used in the excavation scenario (60 cm). Refer to Section E for additional discussion.

D. SURVEY UNIT INVESTIGATIONS PERFORMED AND RESULTS

No investigations were required.

E. SURVEY UNIT DATA ASSESSMENT

The Forebay dike soil DCGL was developed assuming that a 2 foot (24 inch) band of soil contaminated at the DCGL exists underneath the rip-rap in the Forebay dikes. The 2 foot assumption was arbitrarily made based upon a minimum amount of data. In order to determine the actual extent of contamination within this band of soil, Maine Yankee performed extensive characterization using samples obtained from inclined core bores beneath the rip-rap as close to the rip-rap as possible. Overall, the Forebay dike soil coring campaign showed that radiological contamination had not penetrated into the Forebay dikes beyond the rip-rap to any substantial depth (likely less than several inches).

The ISOCS measurements of the Forebay dike soil through the rip-rap were geometrically configured such that the entire photon spectra was attributed to a contaminated soil band of 6 inches. Thus, this activity, attributed to a 6-inch band, should be divided by a factor of four in order to appropriately compare it to a DCGL which was developed assuming a 24-inch band of contaminated soil. This adjustment is also applicable to soil samples obtained at depths of 0" to 6" and is justified since the Forebay dike core boring campaign demonstrated that contamination had not penetrated into the Forebay dike beyond the rip-rap to any significant extent. The survey results for FR-0400 Survey Unit 2 were evaluated using this methodology.

An analysis of the direct sample measurement results, including the mean, median, standard deviation, and sample result range, are provided in Table 2. The sampling results yielded three samples with Cs-137 and two samples with both Cs-137 and Co-60. All samples were well below the Cs-137 and Co-60 DCGLs of 34.76 pCi/g and 12.01 pCi/g, respectively. The maximum combined Cs-137 and Co-60 results were approximately 1.2% of the unitized DCGL.

The ISOCS scan data was evaluated using the DCGLs stated above. All results were below the Cs-137 and Co-60 DCGL. Therefore, no investigations were required. The results also ensure that there are no unevaluated areas exceeding the DCGL_{EMC} values shown in Table 2-2.

For illustrative purposes, as indicated in LTP Section 5.9.3, a simplified general retrospective dose estimate can be calculated from the average residual contamination level by subtracting the established mean fallout Cs-137 background value of 0.19 pCi/g (Reference 5) for disturbed soil from the survey unit mean (0.098 pCi/g) yields a negative value which is equivalent to 0.0 mrem/y. Conversely, the annual dose contribution from Co-60 is determined by dividing the survey unit mean (0.07 pCi/g) by the DCGL and the factor of four as discussed above. This value is multiplied by the survey unit dose (9 mrem/y) assuming the survey unit mean is equal to the DCGL. The result is an annual dose of 0.014 mrem/y.⁴

⁴ This annual dose equivalent is based on the revised Forebay technical basis document (Reference 6) which shows that the excavation scenario DCGL equals 9 mrem/y ($0.07/12.01 \times \frac{1}{4} \times 9 = 0.014$ mrem/y).

F. ADDITIONAL DATA EVALUATION

Attachment 4 provides additional data evaluation associated with this Survey Unit, including relevant statistical information. Based on survey unit direct measurement data, this attachment provides the Sign Test Summary, Quantile Plot, Histogram, and Retrospective Power Curve.

1. The Sign Test Summary provides an overall summary of design input and resulting calculated values used to determine the required number (N) of direct measurements (per LTP Section 5.4.2). The Sign Test Summary is a separate statistical analysis that also calculates the mean, median, and standard deviation of the direct measurements.

The critical value and the result of the Sign Test are provided in the Sign Test Summary table, as well as a listing of the key release criteria. As is shown in the table, all of the key release criteria were clearly satisfied for the FSS of this survey unit.

2. The Quantile Plot was generated from direct measurement data listed in Table 2. The data set and plot are consistent with expectations for a Class 1 survey unit. All of the measurements are well below the DCGL of 12 pCi/g Co-60 and 34.76 pCi/g Cs-137.
3. A Histogram Plot was also developed based on the direct measurement values. This plot shows that the direct data were essentially by a log-normal distribution with one outlier.
4. A Retrospective Power Curve was constructed, based on FSS results. The curve shows that this survey unit having a mean residual activity at a small fraction of the DCGL has a high probability ("power") of meeting the release criteria. Thus, it can be concluded that the direct measurement data support rejection of the null hypothesis, providing high confidence that the survey unit satisfied the release criteria and that the data quality objectives were met.

G. CHANGES IN INITIAL SURVEY UNIT ASSUMPTIONS ON THE EXTENT OF RESIDUAL ACTIVITY

The survey was designed as a Class 1 area. The FSS results were consistent with that classification. Due to remediation activities, the source term appears to have increased Cs-137 to Co-60 ratios. This was addressed by including Cs-137 in the evaluation of the survey results. As discussed in Section E, a soil boring campaign demonstrated that the depth of contamination in the Forebay dikes was much less than the assumed value in the dose model. The data evaluation removed this conservatism. The direct measurement sample standard deviation was less than the design sigma. Thus, a sufficient number of samples were obtained.

H. LTP CHANGES SUBSEQUENT TO SURVEY UNIT FSS

The FSS of Survey Unit 2 was designed and performed using the criteria of the approved Forebay Technical Basis Document (Reference 4) and LTP Revision 3 Addenda (Reference 1 and 2). Because of the FR 0400 EMC issues identified during the final data review (Reference Condition Report, CR 04-161), the soil excavation scenario was modified to increase the Forebay soil DCGL to a value which was equivalent to 90% (9 mrem/y) of the limit (10 mrem/y) allowed for soil outside the RA. This change raised the DCGLs for Co-60 and Cs-137 to 12.01 and 34.76 pCi/g respectively. The soil area factors were applied to these values to derive the appropriate DCGL_{EMC}. These changes are documented in Reference 6. There were no other LTP changes that affected the survey design or results for the survey unit.

I. CONCLUSION

The FSS of this survey unit was designed based on the LTP designation as a Class 1 area. The survey design parameters are presented in Table 1. The required number of direct measurements was determined for the Sign Test in accordance with the LTP. As presented in Table 2, all direct measurements were less than the DCGL of 12 pCi/g Co-60 and 34 pCi/g Cs-137.

A Sign Test Summary analysis demonstrated that the Sign Test criteria were satisfied. The direct measurement sigma was determined to be less than that used for design, thus indicating that a sufficient number of samples was taken.

The Retrospective Power Curve shown in Attachment 4 confirmed that sufficient samples were taken to support rejection of the null hypothesis, providing high confidence that the survey unit satisfied the release criteria and the data quality objectives were met. Attachment 4 also revealed that direct measurement data represented essentially a log-normal distribution, with variance consistent with expectations for a Class 1 survey unit.

The scan survey design for this survey unit was developed in accordance with the Forebay Technical Basis Document with significant aspects of the design discussed in Section B and Table 1. Scanning resulted in no areas with activity above the investigation levels; therefore, no investigations were required.

It is concluded that FR0400 Survey Unit 2 meets the release criteria of 10CFR20.1402 and the State of Maine enhanced criteria.

J. REFERENCES

1. Maine Yankee License Termination Plan, Revision 3, October 15, 2002
2. Maine Yankee letter to the NRC, MN-02-061, dated November 26, 2002
3. NRC letter to Maine Yankee, dated February 28, 2003
4. Maine Yankee letter to the NRC, MN-03-051, "Forebay Technical Basis Document," dated September 3, 2003
5. Approach for Dealing with Background Radioactivity for Maine Yankee Final Status Surveys, Attachment E to Maine Yankee Procedure PMP 6.7.8, FSS Data Processing and Reporting
6. Maine Yankee Calculation EC-041-01, Diffuser and Forebay Dose Assessment
7. Maine Yankee Calculation EC-003-04, Use of Canberra In Situ Object Counting System (ISOCS) for FSS Surveys

Attachment 1

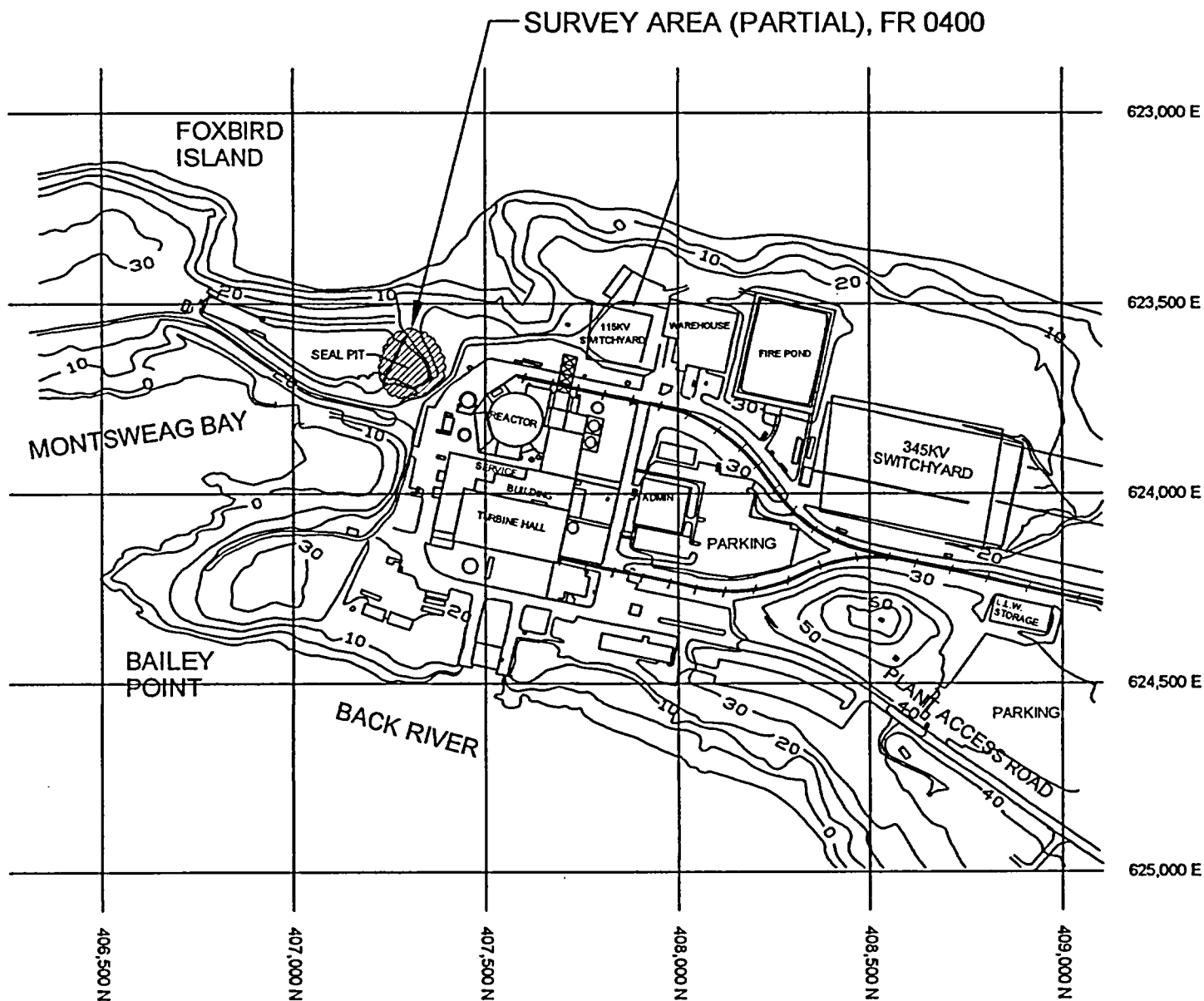
Survey Unit Maps

Survey Type: ☐ Remediation

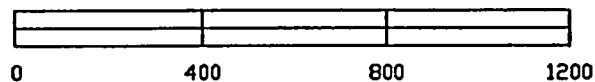
☐ Turnover

☒ Final Status Survey

Survey Area Name: Forebay Seal Pit Site Map

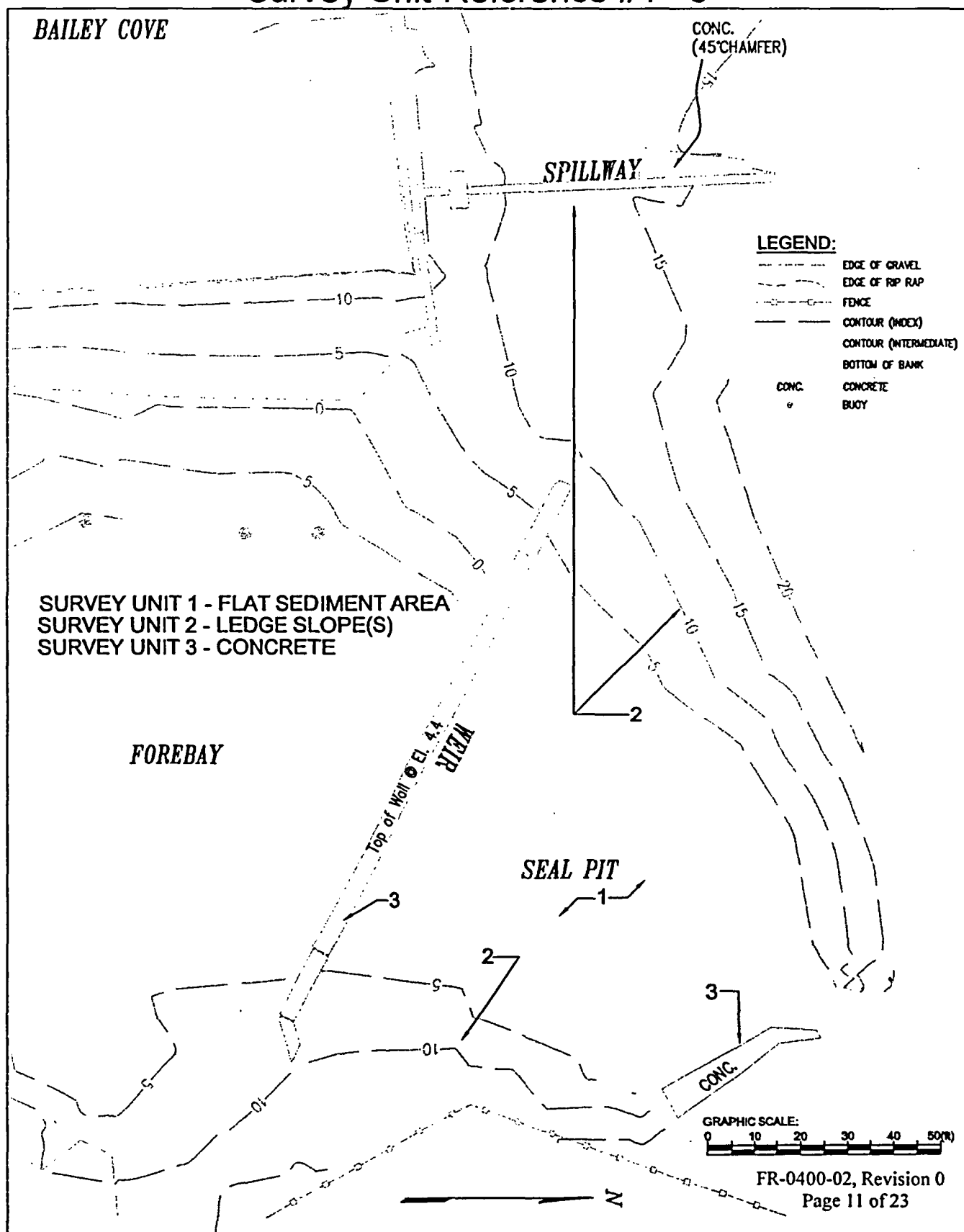


SCALE



Note: Grid based on Maine State Coordinate System
(West Zone) NAD 1927

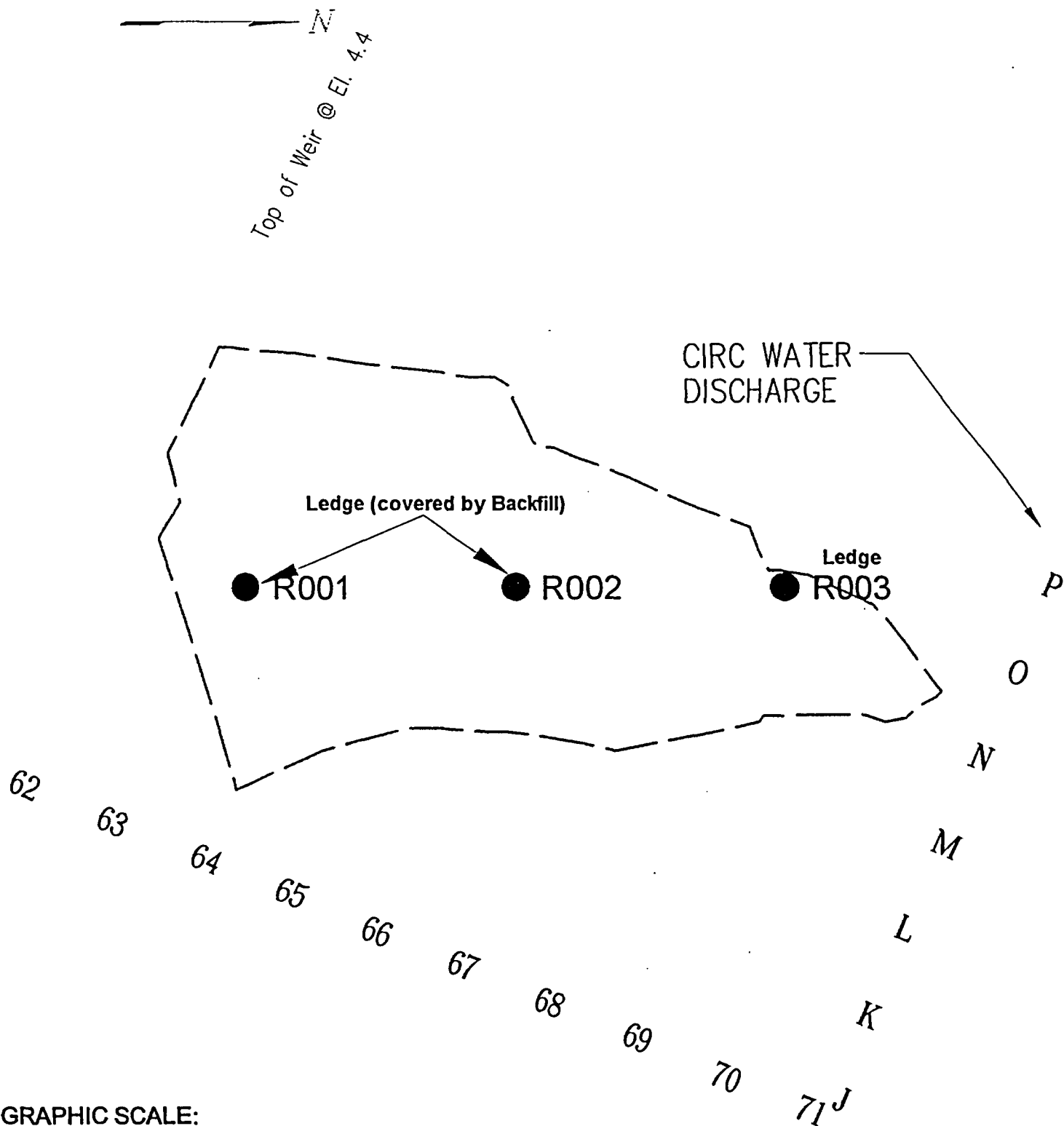
Seal Pit FSS Survey Unit Reference #1 - 3



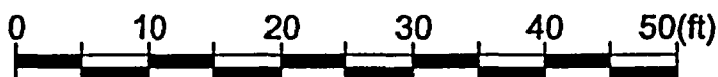
Survey Type: ☐ Investigation ☐ Turnover ☒ Final Status Survey

Survey Area Name: FR 0400, Forebay Seal Pit

FR0400 SU2: Forebay Seal Pit East Bank Direct Points R001 - R003



GRAPHIC SCALE:



FR-0400-02, Revision 0

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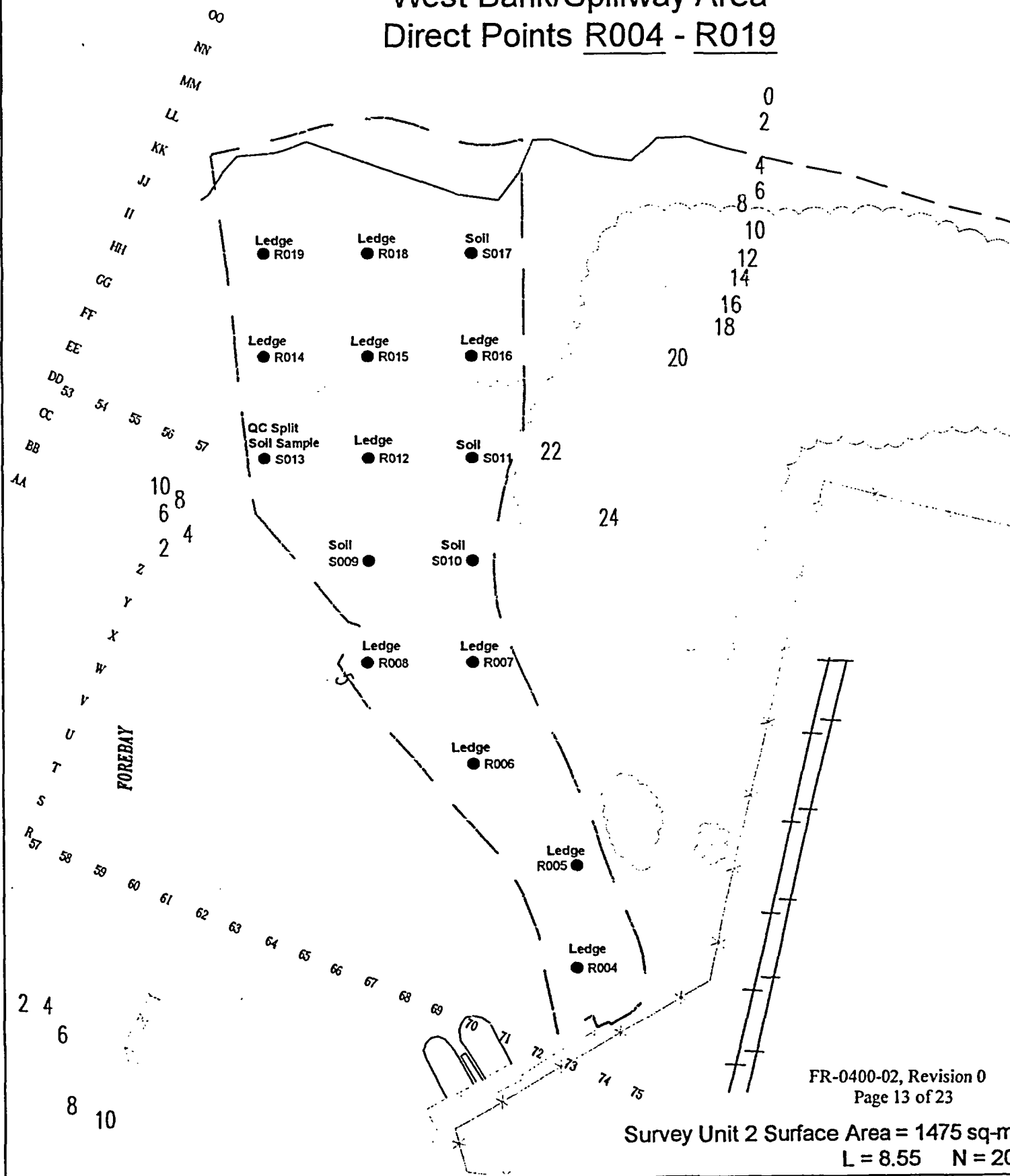
Survey Unit 2 Surface Area = 1475 sq-m

L = 8.55 N = 20

Survey Type: ☐ Investigation ☐ Turnover ☒ Final Status Survey

Survey Area Name: Forebay Seal Pit West Slope

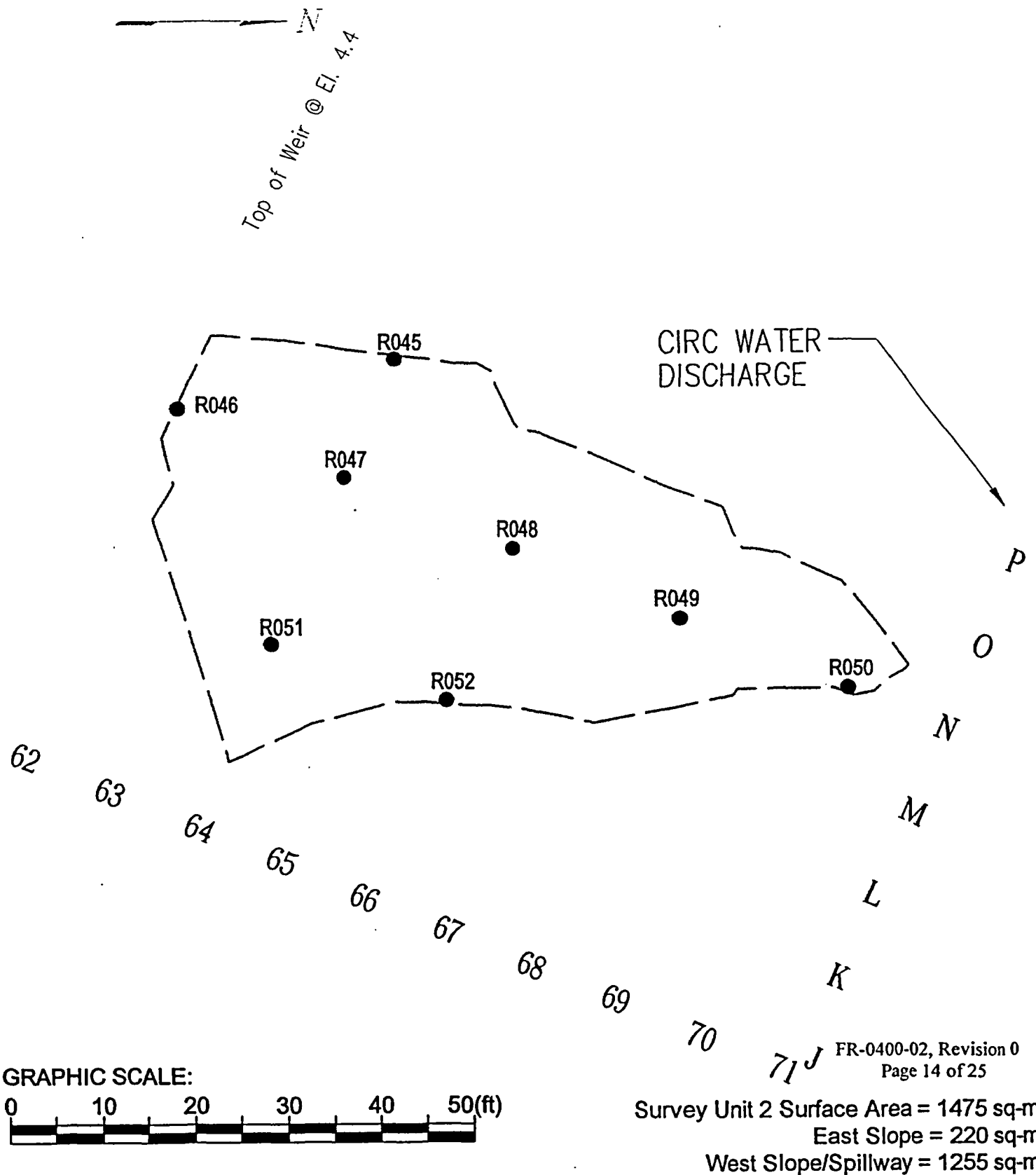
FR0400 SU2: Forebay Seal Pit West Bank/Spillway Area Direct Points R004 - R019



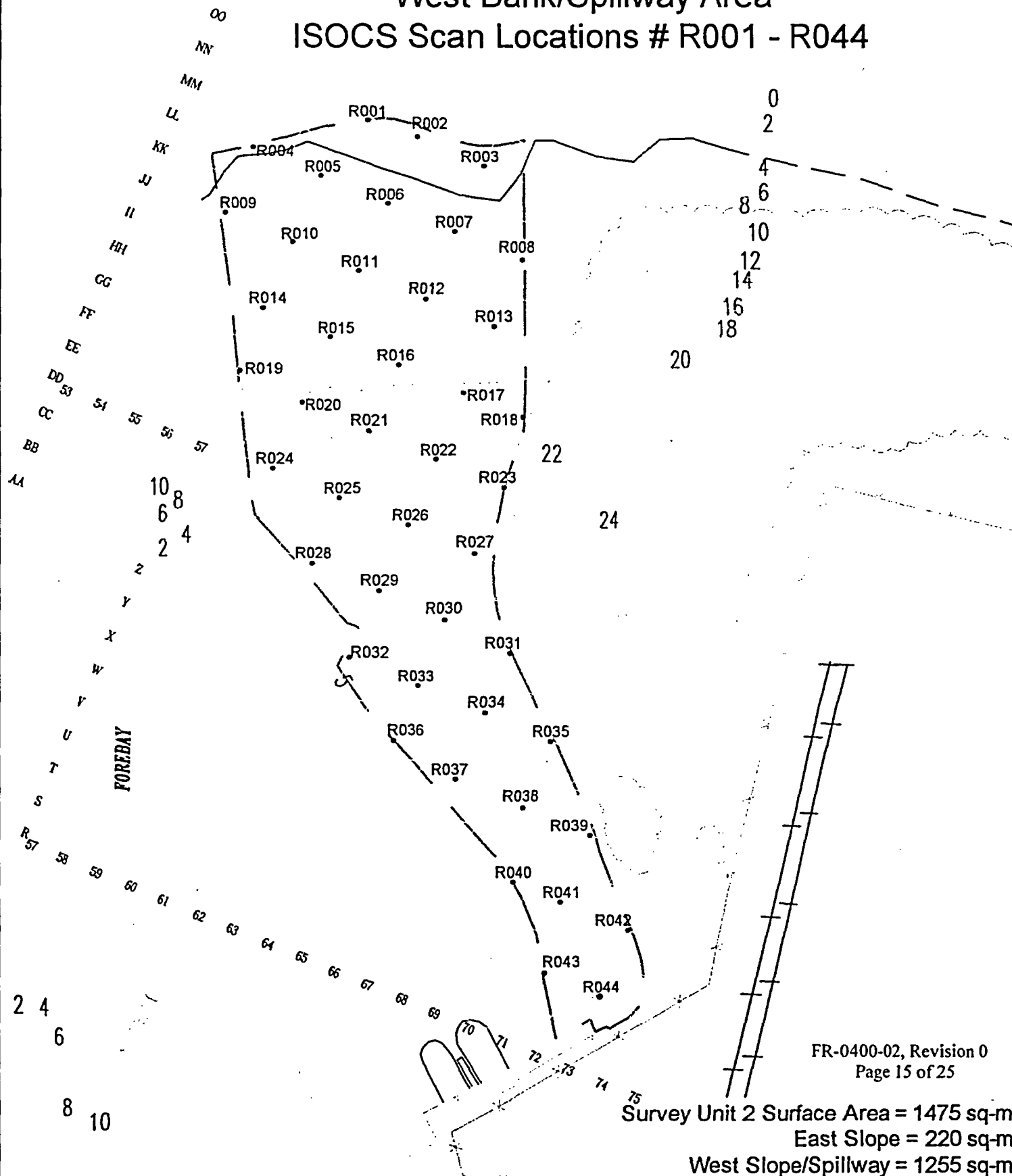
Survey Type: ☐ Remediation ☐ Turnover ☒ Final Status Survey

Survey Area Name: FR 0400, Forebay Seal Pit

FR0400 SU2: Forebay Seal Pit East Bank ISOCS Scan Locations # R045 - R052



Survey Area Name: Forebay Seal Pit West Slope



Attachment 2

Survey Unit Instrumentation

TABLE 2-1

INSTRUMENT INFORMATION

| Detector | Design Scan MDC |
|----------|-----------------|
| 7605 | See Table 2-2 |
| 7607 | See Table 2-2 |

HPGe Detectors for Lab Analysis of Volumetric Samples

| Detector Number | MDC (pCi/g) |
|-----------------|-------------|
| FSS-1 (HPGe) | 0.05 – 0.10 |
| FSS-2 (HPGe) | 0.05 – 0.10 |
| DET-2 (HPGe) | 0.05 – 0.10 |

TABLE 2-2

**INSTRUMENT SCAN MDC AND COMPARISON WITH DCGL_w
AND DESIGN DCGL_{EMC}**

| Detector | ISOCS | Comments |
|----------------------------|---------------------------------------|--|
| ISOCS Scan MDC | MDC < 7 pCi/g Co-60 | |
| DCGL | 12 pCi/g Co-60 34.76 pCi/g Cs-137 | Reference 6 |
| Investigation Level | 12 pCi/g Co-60 34.76 pCi/g Cs-137 | < DCGL _{EMC} |
| Design DCGL _{EMC} | 16.8 pCi/g Co-60 48.7 pCi/g Cs-137 | DCGL x 1.4 (1.4 is the actual AF for surface soil, LTP Table 6-12) |

Attachment 3

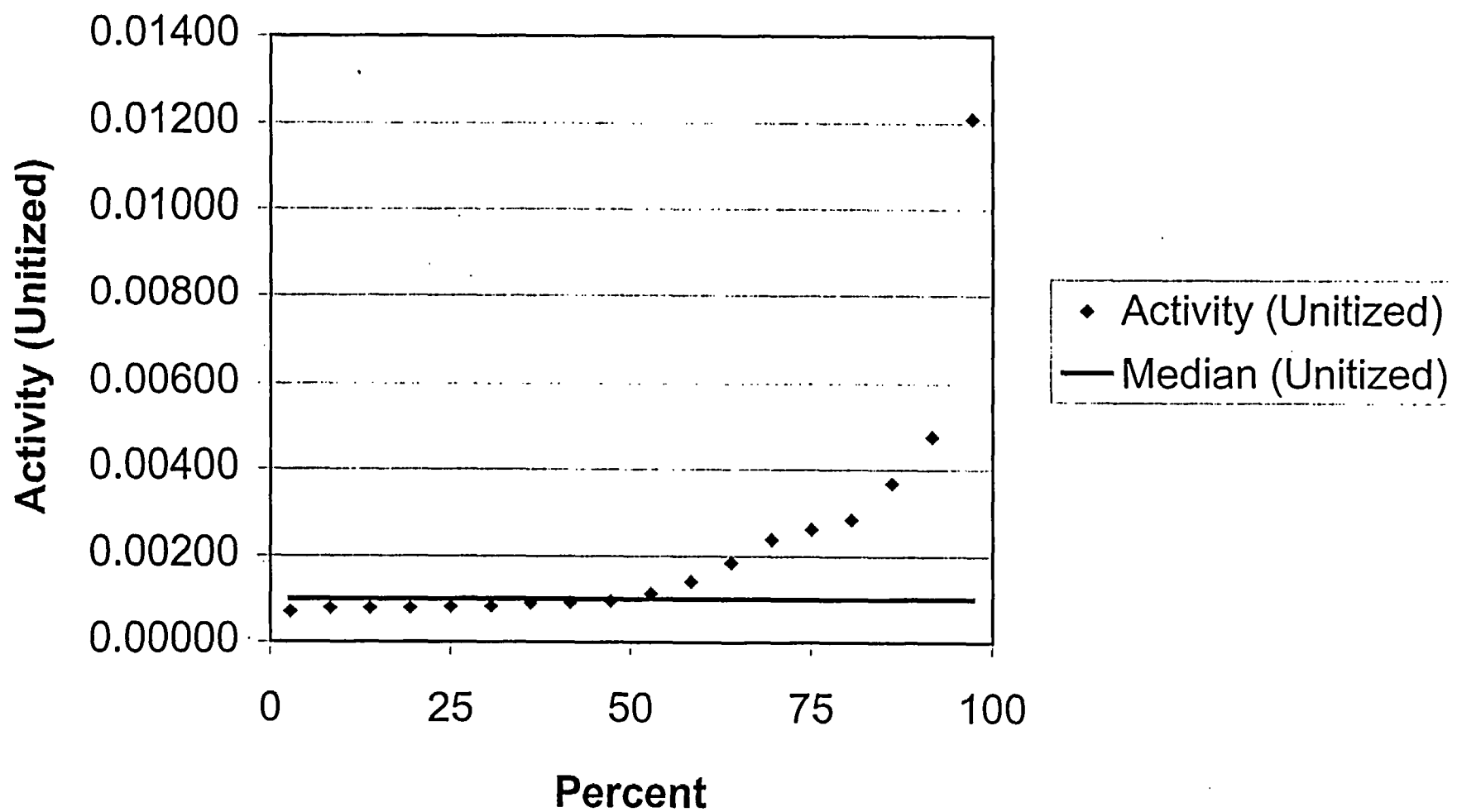
Investigation Table
(No Investigations Required)

Attachment 4
Statistical Data

Survey Package FR0400 Unit 2 Soil Sign Test Summary

| Evaluation Input Values | | Comments |
|--|----------|----------------------------------|
| Survey Package: | FR0400 | Sealpit banks |
| Survey Unit: | 02 | |
| Evaluator: | DR | |
| DCGL _w : | 1.00E+00 | |
| DCGL _{emc} : | 1.40E+00 | |
| LBGR: | 5.00E-01 | |
| Sigma: | 1.82E-01 | (2.18 pCi/g / 12pCi/g) |
| Type I error: | 0.05 | |
| Type II error: | 0.05 | |
| Nuclide: | UNITY | |
| Soil Type: | N/A | |
| Calculated Values | | Comments |
| Z _{1-α} : | 1.645 | |
| Z _{1-β} : | 1.645 | |
| Sign p: | 0.99379 | |
| Calculated Relative Shift: | 2.7 | |
| Relative Shift Used: | 2.7 | Uses 3.0 if Relative Shift is >3 |
| N-Value: | 12 | |
| N-Value+20%: | 15 | |
| Sample Data Values | | Comments |
| Number of Samples: | 18 | |
| Median: | 1.04E-03 | |
| Mean: | 2.23E-03 | |
| Net Sample Standard Deviation: | 2.72E-03 | |
| Total Standard Deviation: | 2.72E-03 | SRSS |
| Maximum: | 1.21E-02 | |
| Sign Test Results | | Comments |
| Adjusted N Value: | 18 | |
| S+ Value: | 18 | |
| Critical Value: | 12 | |
| Sign test results: | Pass | |
| Criteria Satisfaction | | Comments |
| Sufficient samples collected: | Pass | |
| Maximum value <DCGL _w : | Pass | |
| Median value <DCGL _w : | Pass | |
| Mean value <DCGL _w : | Pass | |
| Maximum value <DCGL _{emc} : | Pass | |
| Total Standard Deviation <=Sigma: | Pass | |
| Criteria comparison results: | Pass | |
| Final Status | | Comments |
| The survey unit passes all conditions: | Pass | |

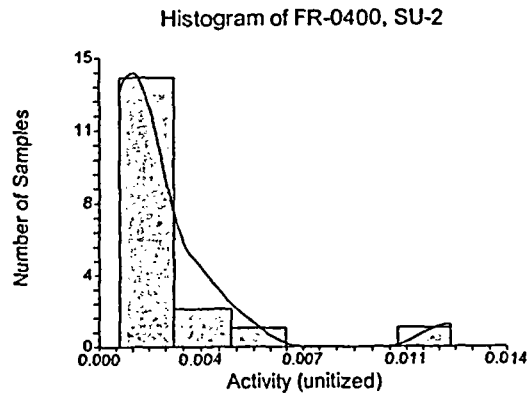
FR-0400 SU-2 Quantile Plot



One-Sample T-Test Report

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Variable C2

Plots Section



One-Sample T-Test Power Analysis

Page/Date/Time 2 12/16/04 5:19:02 AM

Chart Section

