CORRO-CONSULTA

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Memorandum

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Subject: Review of Fitness for Service Assessment of Oyster Creek Dry Well on the Basis of Extended Data Analysis

I. Objective

One of the basic questions involved in the relicensing of the Oyster Creek nuclear power generating station aims at assessing the confidence one might have in the continued integrity of the *corroded and damaged* Dry Well Shell, the primary radiation barrier in case of an event. Specifically, should Oyster Creek continue to operate for another 20 years, and should corrosion continue, even at a low rate, one needs to define the remaining margins with a high degree of confidence in order to determine the frequency of monitoring.

It is the objective of this study to review all external wall thickness measurements from 1993 and 2006 in order to determine how well one understands the corrosion damage at this time and how much confidence one can have in the remaining margins.

II. Summary

A statistical analysis was performed of all available external corrosion data measured in various Bays in 1992/1993 and 2006.

Since there were duplicate and in some cases triplicate UT measurements available for several locations each in Bays 5, 7, 15, and 19, it was possible to establish a solid standard deviation for these UT measurements. Although these standard deviations varied somewhat with the extent and severity of corrosion from Bay to Bay, where severe corrosion existed the standard deviation of the measurements is between 40 and 50 mils for 95% confidence limits of +/- 90 mils.

The interpretation of the data for the individual Bays was aided by "Contour Plots" which are three-dimensional plots of contours of equal wall thickness within the space of the UT measurements.

The paucity of data, particularly in the heavily corroded Bays makes definite conclusions very difficult and an assessment of the extent of the corroded areas somewhat intuitive.

Nevertheless, taking into consideration the inherent variability of the measurements and the overall paucity of the data, it is my view that the data do not allow AmerGen to show that the drywell currently meets the safety requirements at the 95% confidence level. Indeed, the extent of the corroded areas in the drywell shell is probably already larger than permitted by most versions of the acceptance criteria.

III. Background

Traditionally, corrosion of the Dry Well Liner in the sandbed area was monitored from the inside by means of UT wall thickness measurements with the help of 6 inch by 6 inch templates placed strategically such that corrosion damage could be monitored in locations corresponding to the top of the sand bed. However, a previous study (**Ref. 1)** demonstrated unequivocally on the basis of the UT data presented by AmerGen that the inside measurements obtained by means of the templates were not representative of the entire corrosion damage and severity of corrosion having occurred in the sandbed area.

The present study takes a closer look at the available UT wall thickness data obtained from the outside and below the top of the former sandbed. The locations for such measurements had been determined on the basis of "*visual observations*", since presumably it had been deemed too cumbersome and to labor intensive to examine each bay in its entirety. The results of this analysis are then discussed in the light of the general and local wall thickness criteria, which had been derived from "buckling models" and other engineering specifications (**Ref. 2)**. The confidence one may have in the current assessment of the nature, extent and severity of the corrosion damage will then:

- support the assessment of the remaining margins
- And together with estimates of future corrosion rates (pitting rates) suggest the applicable monitoring frequencies.

We do not intend to take issue with the pertinent structural questions, such as the derivation of the minimum wall thickness criteria, (even though their definitions and application have varied over the years), nor will we discuss the methodologies of obtaining the wall thickness data. We do, however, intend to make use of the available data as reported, and ask the question of how much additional information may be extracted from these data with methods, which may complement those used by AmerGen. Specifically, as we have in the past, we aim at contributing to the aging management plan by critically looking at the available data and by extending and broaden our understanding of what the data may tell us.

IV. Numbers and Numbers

It is well to remember that there are two kinds of number, absolute ones and estimates. If a number, such as the minimum acceptable wall thickness of 0.736 inches is derived from a model be means of calculation we would consider that an absolute number valid within the framework of the assumptions which had been made in the development of the model. On the other hand, numbers arrived at by measurements are really only *estimates*, afflicted with a certain probability of reflecting the true reality. It is known that UT measurements have a standard deviation defined by the manufacturer of the device of 1% of wall thickness. Hence a single wall thickness measurement of 0.750 inches reflects (estimates) a true wall thickness value of 0.750 +/- 0.015 inch with a probability of 95%[1)]. In view of the fact that it is difficult to reproducibly put the UT probe at the same location, and therefore to measure the same thickness, the confidence limits with respect to the true thickness at the location in question are larger. In Bay's 5, 15, and 19 repeat measurements were made in 2006. The standard deviation of these repeat measurements was 33, 50, and 43 mils, respectively, resulting in 95% confidence limits of about +/- 90 mils (if pooled). As a consequence of this reality it is difficult to accept AmerGen's assurances which state categorically for instance (Ref. 3, page 59) that: "the average of these three readings is 0.773 inches which is greater than 0.736". Therefore area 5 meets the 0.736 uniform criteria". Taking into consideration that the 95% confidence limit of the average of three measurements is 50 mil, there is more than a 5% probability that the average for area 5 is less than 0.736.

Similarly for areas 7, 8, and 11 in Bay 13 AmerGen states that the average of these three areas is 0.658 inches bounded by a 12" by 12" area. Therefore, this square foot area is greater than the local buckling criteria of 0.636 inches. First one should notice that the 1 square foot area has been bounded quite arbitrarily and could as well have been 24" by 24". Furthermore, the average of 658 mils for three measurements in reality is 658 +/- 52 mil such that the real value with 95% probability lies somewhere between 700 and 608 mils. We realize that this spread of the results and this uncertainty in the data is uncomfortable, however, it is based on AmerGen's data and classical statistical evaluation.

[1)] Older instruments, such as were available in the late 1980's to early 1990's may have had a standard deviation more like 2% of wall thickness.

V. The Inherent Difficulties

The available models, which had been used to assess buckling (for instance), rely on uniform thinning over a large (or relatively small area as the case may be). Thus, a minimum wall thickness of 0.736 inches has been defined for the Dry Well Shell. This meant that if the Liner had been corroded down to a remaining wall thickness of 0.736 inches over an area embracing the height of the former sandbed and extending the length of one bay a real danger would exist that the Shell might "buckle". (For smaller areas the minimum wall thickness may be smaller as will be discussed below).

It is, however, well established, that corrosion did not occur in a uniform manner (see e.g. repeated references to the "golf ball like" aspects of the corroded surfaces). Additionally, the remaining wall thickness in the sandbed area was determined by ultrasonic "point measurements" at what appears to be random locations [2)] below the vent pipes in each bay but not extending far into the respective bays.

As a consequence of this situation it became necessary to convert random point measurements of the wall thickness over a highly non-uniform surface to an average wall thickness for this same surface area. In principle this can only be done properly if the surface had been scanned. However, in view of the location and accessibility of "sand bed surfaces" ultra sonic scanning may not have been possible in 1992 after the removal of the sand.

In order to escape this dilemma AmerGen presented a model (**Ref. 3),** which essentially says that if the deepest pit (thinnest remaining wall thickness) had been located all other measurements would show larger wall thicknesses, and therefore an average wall thickness could be calculated between the thinnest and surrounding locations and this average could then be compared to the criteria. Clearly this is the only approach one can take, however, it also depends on how close together the point measurements are. AmerGen indicates that the point measurements cover an area with diameter of 2.5 inches. Hence, if point measurements are not further removed than 2.5 inches (center to center) from each other, the assumption is correct. If however the point-measurements are more than say 5 inches apart, there can be no assurance that not a deeper pit may exist between the two under consideration [3)]. **The confidence one can have in AmerGen's assessment of the remaining wall thickness over the measured area depends on the density of the measurements.** We wish this "confidence" could be expressed in a number, but we think this is not

[2)] While the inside measurements were made with the help of a 6 inch by 6 inch template which could be placed in exactly the same position each time measurements were made, the outside measurement locations needed to be described with coordinates referenced to a specific point below the vent pipe for each bay. The exact location of this reference point relative to the centerline of the vent pipe may vary from bay to bay.

[3)] AmerGen has given assurances that the inspector charged with making the measurements had selected the deepest corrosion features (thinnest wall thickness) by visual observation. We think that it would be quite difficult to discriminate between two corrosion features within +/- 0.05 inches. 0.05 inches, however, is of the order of the remaining margin in many areas.

possible. However, we can look at the situation and gain intuitive insight into this question. Figure 1, which is discussed in detail below, presents areas of equal wall thickness (contours) based on the measurements, shown as the points, performed on the outside of Bay 19 in 2006. Note the dark squares are 2.5 inch on each side (and drawn to scale with reference to the horizontal axis), hence cover the area of measurement claimed by AmerGen. It turns out that the measurements at the –20 (inch) vertical position are on average less than 0.725 inches. Since measurements had not been extended to higher elevations one has no assurance that there are no more seriously corroded areas either between those measured or further up in the sandbed.

A detailed explanation and discussion of these graphs will be offered below. At this point it must be pointed out that in general (with few exceptions) the locations chosen for UT measurements on the outside of the Dry Well Liner are few and far between, and that calculating averages between them cannot possibly lead to results with a high degree of confidence.

VI. The development of Contour Plots

Nevertheless, averages we must calculate or else we could not apply the wall thickness criteria, which have been established with considerable effort, and apply them to specified surface areas.

AmerGen went to considerable effort to attempt to demonstrate that essentially no corroded areas exceed the minimum wall thickness criteria. What AmerGen did essentially is to calculate averages from a limited set of measurements either in the y or x directions. Subsequently it estimated the surface area surrounding these points. Finally, average wall thickness and associated surface area were compared to the criteria. While AmerGen thus performed a one-dimensional analysis we propose here to perform a two dimensional analysis.

A simple statistical principle says there is "power in data" and the more data one can bring to bear on a statistical analysis, the more confidence one can have in the results. A typical example is the analysis of variance. Where experimental results have been obtained as a function of several parameters, one wants to evaluate the results using all the data over the entire parameter field, rather than studying each effect individually.

Similarly, in the present case where thickness data have been obtained as a function of horizontal and vertical distance from a reference point one wants to use all the data for an analysis rather than study variations along each axis individually, or specific arbitrarily chosen areas. Such a procedure is possible by using "triangulation" over the entire x - y field. Triangulation essentially calculates averages between all points instead of just some points. For example, take any point in Fig. 1 and connect it with any other point in its vicinity, then calculate the average between each pair and associate the coordinates to this average. Using all this data an algorithm now calculates equal response lines in the two-dimensional x/y field, in this case, lines of equal wall thickness over the area, which comprises the measurements. The areas between the lines can be shaded. In this manner, Figure 1 shows the areas where it is estimated that the residual wall thickness is between 0.800 and 0.750 inches or less than 0.750 inches, etc. Lines of equal response can be spaced closer together (each 25 mils) or farther apart. In this case, because the inherent inaccuracy of the measurements themselves and the paucity of data it was judged that spacing the lines closer together would not contribute additional insight.

The advantage of this evaluation is that one can see all the available data in a quantitative presentation. Thus, one can see in Figure 1 that an area exists at elevation –20 (20 inches below the reference point) where the remaining wall thickness is less than 750 mils, or less than the criteria for general thinning at 95% confidence. This area extends from 20 inches on the left (-20 inches) to about 60 inches on the right (+60 inches), or about 7 feet. The width of this area in Fig. 1 is maybe 4 to 5 inches, however, because measurements were not extended toward lesser elevations (from the reference point) one simply cannot estimate how much further the serious the corrosion may extend in Bay 19.

In summary, the three-dimensional presentation of the UT wall thickness measurements does two important things for us:

- It presents all data as whole over the area that has been examined and where information exists
- It also indicates where information should have been gathered but wasn't. We therefore get a much better picture with respect to the confidence one may have in the results of the monitoring data.

VII. AmerGen's Treatment of the Raw UT Measurements

AmerGen perceived a difficulty with the UT measurements as far back as 1992 (Ref. 4) in that UT measurements on a "rough" corroded surface were judged inaccurate. In order to improve the accuracy, or, as the case may be, verify the UT measurements, the pit depths in the locations (areas) where UT measurements had been performed were measured by means of micrometers. However, the pit depths could not be referenced to the original surface because the surface from which the pit depth was measured was itself corroded. It was apparently felt that the micrometer measurements would need to be corrected themselves because of the corroded nature of the surface ("golf ball like pimples"). Therefore an imprint was made of the surface and the roughness assessed on the imprint by means of micrometers again. These measurements, about 40 randomly chosen over an area of 40" by 40" were averaged and the average plus one (1) standard deviation was used as a "conservative estimate of the roughness of the surface. Now raw UT measurements were corrected to account for the surface roughness and to yield a value called the "Evaluation Thickness" as follows:

$$T_{evaluation}=UT_{measurement}+(\text{AVG Micrometer readings})-T_{roughness}$$

This algorithm appears to correct for the fact that due to the roughness the UT probe may not have "coupled" well with the metal surface and therefore detect less metal (thinner wall) than was actually there. This explanation had not been given in so much detail in the original calculation of 1993 and is in part our interpretation. It turned out that almost all UT measurements were reduced by this correction. However, when the average roughness plus two (2) standard deviations was used, the opposite was the case. Furthermore, we understand that the 2006 measurements were made with the epoxy coating in place. In this case the correction would not apply because the sensor would necessarily have coupled better with the smooth epoxy surface, and the instrument would have compensated for the thickness of the epoxy coat.

We can therefore not accept the evaluations done by AmerGen using the "evaluation thickness). Indeed, Mr. Tamburro himself commented in early 2006 that:

> *The calculation develops a term called "evaluation thickness" based on actual measured thicknesses. This value is then compared to the design basis minimum required uniform thickness for the sandbed region of 0.736 inches. The method in which "evaluation thickness" is developed is poorly explained. In addition the justification as to why it is acceptable to compare the evaluation thickness to the design basis required minimum uniform thickness of 0.736 inches is not documented in the calculation, nor is there a reference to an industry standard. (Ref.5)*

As it turns out, the procedure is used again in Ref. 3, page 23 without any further explanation or justification, other than that the evaluation thicknesses better fulfill the design basis criteria.

Another comment should be made at this point regarding the quality of the data used for the evaluation of fitness for purpose of the Dry Well Shell. Repeated reference is made to the fact that: *in 1992 inspections began with visual inspections to identify the thinnest areas in each bay. UT measurements were then performed on the thinnest points within each area (e.g. Ref.3, page 4 of 183).* One keeps wondering how it is possible to discern "the thinnest points" by visual inspection. No doubt the Dry Well Liner is not corroded uniformly in the former sand bed area. And certainly there are areas that are pitted more severely than others, which is totally consistent with the nature of this type of corrosion and the underlying corrosion mechanism. However, in view of the fact that the margins (difference between design basis thickness and actual UT measurements) are already very thin, one has to wonder how visual inspection can differentiate between areas that might differ by 50 to 75 mils in residual wall thickness. Case in point is repeat measurements in 2006. In Bay 15 for instance, area 1 was first measured as 0.779" residual thickness while repeat measurements are shown to vary from 0.711" to 0.779 inches. Similar variations were found for a large number of the areas in Bay 15 as well as other Bays (Ref. 6).

The difference between the average of the first set of 2006 measurements in Bay 15 and the average of subsequent sets is statistically not significant. The standard deviation for repeat measurements, however, is of the order of 45 mils and the 95% confidence limits are of the order of +/- 90 mils.

AmerGen discusses the bathtub ring in Bay 1 (See also Figure 2) as one single area using 1992 and 2006 data for which the ***evaluation thicknesses*** had been determined (See discussion of evaluation thicknesses above). AmerGen finds that in this area the average of 11 data points, which is around 4 square feet in area, is 0.766 inches and 0.765 inches for the 1992 and 2006 measurements, respectively. Considering the uncertainty of the measurements, +/- 27 mils, there is at least a 5% probability that the remaining margin is of the order of 2 to 3 mils, assuming that areas larger than one square foot in extent must average 0.736 inches or more.

Even more seriously, if the original data as measured in 2006 had been used for this assessment, the average thickness from the 11 measurements would be 0.735. There would therefore be no margin left for corrosion for this particular area, not even taking into consideration that the 95% confidence limits are +/- 27 mils for the average of 735 mils.

At this point we should make a comment concerning the use of statistics. The statistical parameters for a set of data said to belong to the same population, such as the mean, the standard deviation, the 95% confidence limits, etc., are mathematically derived entities based on broadly accepted theory. The central limit theorem says that the standard deviation of the mean is smaller as more data is gathered. Thus, if a mean of 5 measurements is say 745 mils with a standard deviation for the individual measurements of 40 mils, then the 95% confidence limits are +/- (40/((5)^2))*2, or +/- 36 mils, ranging from 781 mils to 709 mils. The probability that this area does not meet design criteria then is of the order of 35 – 40 % (not rigorously determined), while the probability that it does meet it is of course the complement 60 to 65%.

One finds often in the practice of statistics a tendency to disregard statistical assessments in favor of intuitive approaches. For example, one way out of the dilemma is to use 1 sigma, but that would reduce the level of confidence, which is unacceptable here. Large variabilities are often in the nature of the phenomenon to be measured (corroded surfaces being a good example) or in the method of measuring. Only large data sets can overcome these difficulties. The table below may illustrate this situation.

Means, Variability, and Standard Deviation of UT Measurements on Corroded External Surfaces.

Bay	1993 Mean of all Measurements	1993 Variability 1 sigma	2006 Mean of all Measurements	2006 Variability 1 sigma	2006 Standard Deviation
5	0.993	0.053	0.960	0.039	0.033
7	1.005	0.043	1.007	0.028	0.023
15	0.816	0.054	0.810	0.053	0.050
19	0.889	0.077	0.848	0.083	0.043

The variability for the individual measurements reflects the irregularity of corrosion. One would not really expect the remaining wall thicknesses to be uniform over the corroded area. In that sense the spread of the data does not really reflect a standard deviation in the purest sense of the word. However, since a large number of repeat measurements had been carried out at the identical coordinates in Bays 5, 7, 15, and 19, it was possible to calculate a true standard deviation for these measurements. It turns out that this standard deviation is also a function of the degree of corrosion found on the varying surfaces.

VIII. Discussion of Contour Plots

The data used for the analysis are contained in Tables 1 and 2 for Bays 1 and 13 as extracted from AmerGen documents. Presumably, these were the most corroded Bays. Figure 2 shows a contour plot for Bay 1 obtained with the data from 1992. The dimensions of the points in the plot are 2.5 by 2.5 inches. Again, one needs to remember that the specific shape of the contours depends not only on the residual wall thickness measured at the locations indicated, but on the density of measurements as well. (For instance, an additional measurement at coordinates h (-20) v (-25) could completely alter the contours and in all likelihood extend the area of wall thickness below –750 mils [4]).

Nevertheless, it appears in Figure 2 that in the so called “bathtub ring” an extensive area exists with wall thicknesses between 700 and 750 mils (0.75 inches). This area extends well over 52 inches (4^+ feet) and is about 5 inches wide. In view of the fact that UT measurements are at best accurate with a standard deviation of about 45 mils, (95% confidence limits +/-90 mils), this area could well be more extensive.

Figure 3 shows the contours for Bay 1 obtained with the data from the 2006 inspection. The general shapes are the same as in Figure 2 except that here we have sizeable areas with residual wall thicknesses below 725 mils. The unexpected thing is

[4] The spacing of the contours is chosen arbitrarily and lightly different results could be expected for alternate contours. In this case 25 to 50 mils was chosen because, as discussed above, there is essentially no difference, statistically significant, between the “criterion” or 736 mils and a measurement of 750 mil residual wall thickness.

that these areas seem to extend on the left beyond h –40 inches but no measurements are available to verify whether AmerGen did in fact manage to capture all of the most corroded areas as claimed.

Based on Figure 3, together with and assessment of the accuracy (reliability) of the data one must conclude that there is a good likelihood that the entire bathtub ring area extending from 40 to –40 inches on the horizontal axis and from about –30 to perhaps -20 inches on the vertical axis is below the 0.736 inch criteria for general thinning and is, much larger than the one square foot acceptance criterion. (Of course, since this area is the most corroded, it will taper off to higher wall thickness on both sides of the vertical axis). The corroded area is indeed shaped quite irregular, but one could venture a guess that the contoured areas below 750 mils are of the order of 4 to 7 square feet all together. This estimated area does not include the area to the left of -40, which probably contains additional area below 0.750 inches.

Figures 4 and 5 show the contours for Bay 13, 1992 and 2006 data, respectively. Here large areas exist with wall thicknesses below 700 mils and at least two seemingly unconnected areas where the residual wall thickness is less than 650 mils. It could be argued that those heavily corroded areas are less than 1 square foot and therefore are still acceptable according to the 636 mil criterion. However, the heavily corroded area on the left hand side (-20, -20) has not been further explored. One therefore does not know whether it might extend further. Similarly, the area on the right ((40, -7), clearly showing a fairly deep pit, was not further explored and was not even measured in 2006. While in Bay 1 the bathtub ring was at elevation –20 to –25 (from the reference point) in Bay 13 there is no clearly prominent bathtub ring. This may be because it was not there, but it may also be because the measurements were not extended toward elevation –15 and –10. We are therefore left with a great uncertainty as to the true extension of the damage in this Bay.

Figure 6 shows the contours for Bay 15. There is a heavily corroded area at elevation –10 with an extension of 1 ft by about 4.5 feet. However, this area was explored only with 2 measurements and was not extended beyond about 2 feet either side of the centerline. It appears that the majority of the measurements occurred in the non-corroded zones. Interestingly there appears some serious corrosion near the sandbed bottom, but the occurrence was not further explored either.

Figure 1 mentioned previously shows a heavily corroded area in Bay 19 at elevation –20. The extent of this area is highly uncertain because it was not further defined by additional UT measurements toward higher elevations (>-20). Indeed, one could find here an extended bathtub ring area.

Figure 7 shows the contours for Bay 11. Again there is a suggestion of severe corrosion at elevation –20 and no further exploration into the bathtub ring area. Once again, the extent of this area is highly uncertain because it was not further defined by additional UT measurements.

In summary, the contours for these various bays show a consistent but equally disturbing pattern. While AmerGen has consistently assured us that visual observation led to the selection of the locations to be evaluated by UT measurements we also find that assertion was not verified, once severe corrosion had been measured, by further exploring the surroundings. This omission greatly contributes to the uncertainty one must have regarding the integrity of the Dry Well Shell.

IX. Discussion of the Minimum Wall Thickness Criteria

Several minimum wall thickness criteria have been developed by means of a General Electric Company computational model. Of interest was the relationship between the degree of wall thinning and the area over which such thinning occurred. It stands to reason that the greater the thinning the smaller the thin area one could tolerate would have to be.

The first criterion so derived states that the limiting wall thickness in one bay was 736 mils in the case that the entire Dry Well Surface formerly in contact with the sandbed were uniformly corroded to that depth. This has been interpreted by AmerGen to apply to the mean of the measured thicknesses.

However, individual measurements less than 736 mil residual wall thickness have been observed. For this reason GE conducted a sensitivity analysis in order to determine the extent of corroded surface area still acceptable when the residual wall thickness was below 736 mils.

The analysis technique embedded in the GE Model the case of a local area of 12 inch by 12 inch having a residual wall thickness of 0.536 or 0.636 inches tapering back to 0.736 inches over a further foot. The theoretical load factor for this case was reduced by 9.5% for the 0.536 inches case and 3.9% for the 0.636 inches case. The safety factor in the first case of general wall thinning is 2 (as required by the ASME code). Therefore, allowable reductions in load factor should get less as the average thickness of the sand bed approaches the general wall criterion.

The following wall thickness acceptance criteria were derived from this model:

- If an area is less than 0.736 inches thick then that area shall be greater than 0.693 inches thick, and shall be no larger than 6 inches by 6 inches. C-1302-187-5320-024 has previously placed an area of this magnitude in Bay 13 **(Ref.2)** [5)] Actually, as can be seen from Figure 4, there are two such areas in Bay 13.

- Most recently, the limiting wall thickness criterion was formulated as follows: *An evaluated area for local buckling shall not be greater than 36 inches by 36 inches wide. The center of the area shall be no larger than 12*

[5)] please note that this reference is dated 12/15/06. This date is important, because it follows a detailed critique of the GE Model results by the same author dated 6/30/06.

inch by 12 inch and shall be on average 0.636 inch thick or thicker. The surrounding 36" by 36" area centered on the 12" by 12" area shall be on average thicker than the transition from 0.636" to 0.736".

This definition, most recently formulated (3/21/07) appears to be saying that the allowable area thinner than 0.736 inches is 9 square feet, but that no 12 inch by 12 inch area of 0.636 inch or less wall thickness should be present. However, it seems to us that this definition is in stark contrast to earlier more conservative interpretations, which limited the area thinner than 0.736 inches to one square foot or less.

An additional criterion relates to the pressure effect and essentially states that an area of 2.5 inch by 2.5 inch must have a wall thickness larger than 0.490 inches.

The real question then is this: If for general thinning of the wall in one bay the residual acceptable wall thickness is close to 0.736 inches how much additional reduction in load factor (or safety factor) can one tolerate if there are local areas with thinner, or much thinner wall thicknesses. We have not found an answer to this question.

X. General Questions and Reservations

For local areas corroded beyond the thickness of 0.736 inches the most stringent criterion derived from the GE calculations states that:

-if an area is less than 0.736 inches thick, then that area shall be greater than 0.693 inches and shall be no larger than 6 inch by 6 inch wide.

Such areas definitely exist in Bays 1 and 13. However, while apparently the criterion was derived for square areas, such areas do not exist in reality. Rather, the major area in Bay 1 which has wall thicknesses below 0.736 inches (and somewhere between 650 and 720 mils) is of the order of 80 inches by 5 inches. If total area rather than linear dimensions are important then the area in Bay 1 which is below 736 mils is 10 times larger than specified by the criteria (400 square inches vs. 36 square inches). There is another area in Bay 1 clearly below 725 mils about 10 inch by 10 in dimensions.

Finally, the acceptance criteria have been based on modeling of square areas of corrosion less than 0.736 inches. However, in Bays 1, 15 and 19 the most corroded areas are actually long grooves. It is likely that such grooves have more effect on the stability of the drywell shell than square areas because the stresses cannot easily distribute around such areas. In the absence of further modeling of the effect of these shapes on stability, it is prudent to use conservative acceptance criteria to review these grooves, based on the modeling conducted to date, especially in Bays 1 and 15 where the average thickness is, at best, very close to 0.736 inches. Thus, the area below 0.736 inches should at least be smaller than one square foot, and thicker than 0.636 inches on average as it appears AmerGen also decided in 2006, after careful consideration.

References:

1. **Affidavit of Dr. Rudolf H. Hausler, April 25, 2007** (Memorandum to Richard Webster, Esq., *Update of Current knowledge regarding the state of integrity of OCNGS Drywell Liner and comments pertaining to the aging management thereof*)
2. **Sandbed Corrosion Rate Assessment,** Attachment 1, Calculation Sheet C-1302-187-E310-041, Preparer Pete Tamburro , 12/15/06, page 11 of 55, (also OCLR 00019286)
3. **CC-AA-309-1001 Rev.2** Calculation Sheet C-1302-187-5320-024, 3/28/07, page 7 of 183
4. **Calculation Sheet C-1302-187-5320-024, Rev. 0,** 04/16/93, page 5 of 54
5. **AR 00461639 Report:** Peter Tamburro, (*Calc C-1302-187-5320-024 is not clearly documented,)* 06/30/06, page 2 of 5, item 3
6. **AR A2152754 E09,** Passport 00546049 07 (Also OCLR 00018401 through 00018494)

Table 1

Bay 1 UT Measurements for External Corrosion.

Measurement ID	Vertical Position inches	Horizontal Position inches	Remaining Wall Thickness 1992 inches	Remaining Wall Thickness 2006 inches
1	-16	30	720	710
2	-22	17	716	690
3	-23	-3	705	665
4	-24	-33	760	738
5	-24	-45	710	680
6	-48	16	760	731
7	-39	5	700	669
8	-48	0	805	783
9	-36	-38	805	754
10	-16	23	839	824
11	-23	12	714	711
12	-24	-5	724	722
13	-24	-40	792	719
14	-2	35	1147	1151
15	-8	-51	1156	1160
16	-50	40	796	795
17	-48	16	860	846
18	-38	-2	917	899
19	-38	-24	890	856
20	-18	13	965	912
21	-24	15	726	712
22	-32	13	852	854
23	-48	15	850	828

Table 2

Bay 13 UT Measurements for External Corrosion.

Measurement ID	Vertical Position inches	Horizontal Position inches	Remaining Wall Thickness 1992 inches	Remaining Wall Thickness 2006 inches
1a	1	45	672	.
2a	1	38	725	.
3a	-21	48	941	932
1	-6	46	814	873
2	-6	38	615	.
3	-26	42	934	.
4	-12	36	914	873
5	-21	6	715	708
6	-24	-8	655	658
7	-17	-23	618	602
8	-24	-20	718	704
9	-28	4	924	915
10	-28	12	728	741
11	-28	-15	685	669
12	-28	-23	885	886
13	-18	40	932	814
14	-18	8	868	870
15	-20	-9	683	666
16	-20	-29	829	814
17	-9	38	807	.
18	-22	38	825	.
19	-37	38	912	960

Figure 1

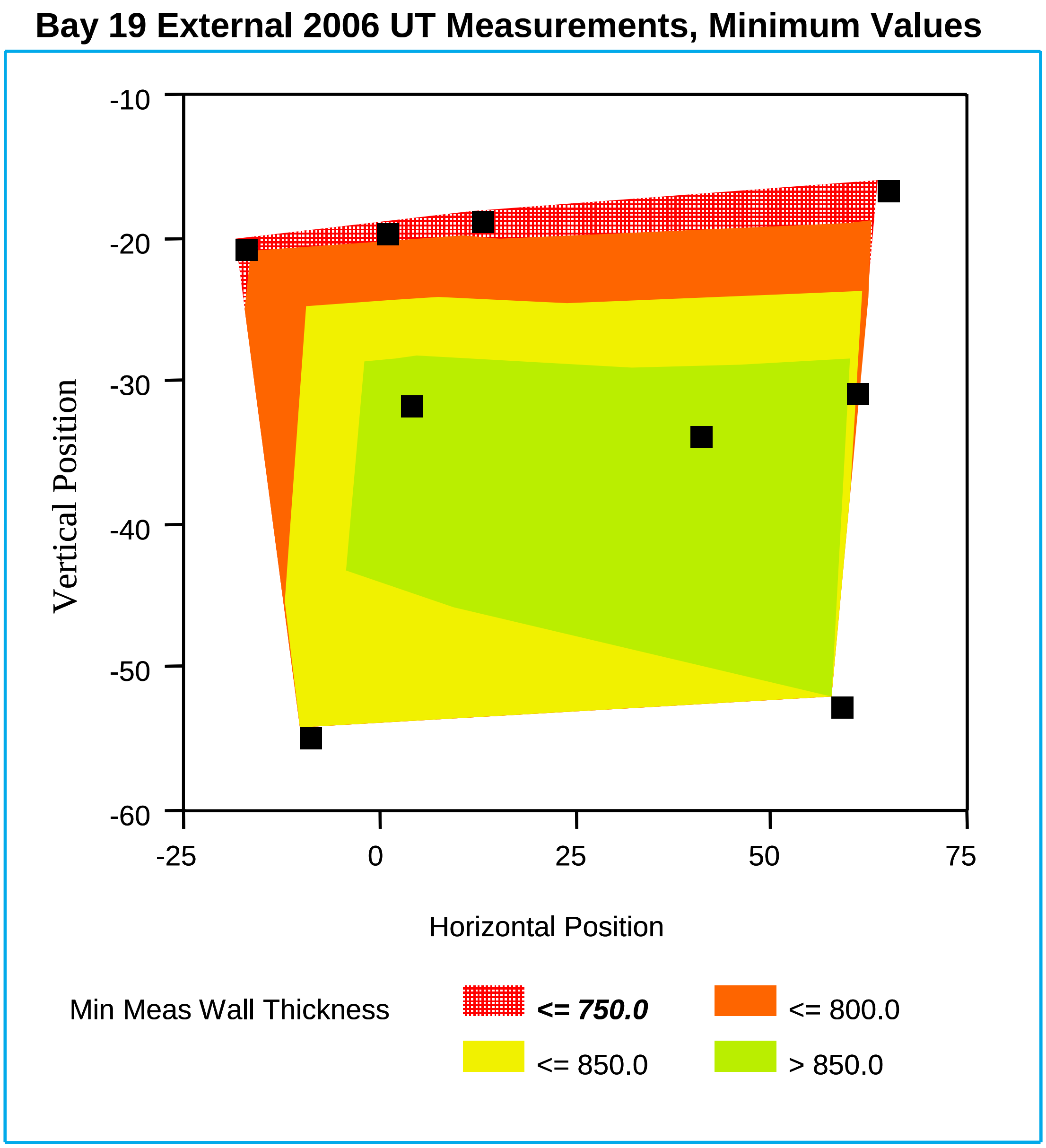

Bay 19 External 2006 UT Measurements, Minimum Values
-10
-20
-30
-40
-50
-60
Vertical Position
-25
0
25
50
75
Horizontal Position
Min Meas Wall Thickness
<= 750.0
<= 800.0
<= 850.0
> 850.0

Figure 2
Bay 1 Remaining Wall thickness
External UT Measurements 1992/1993

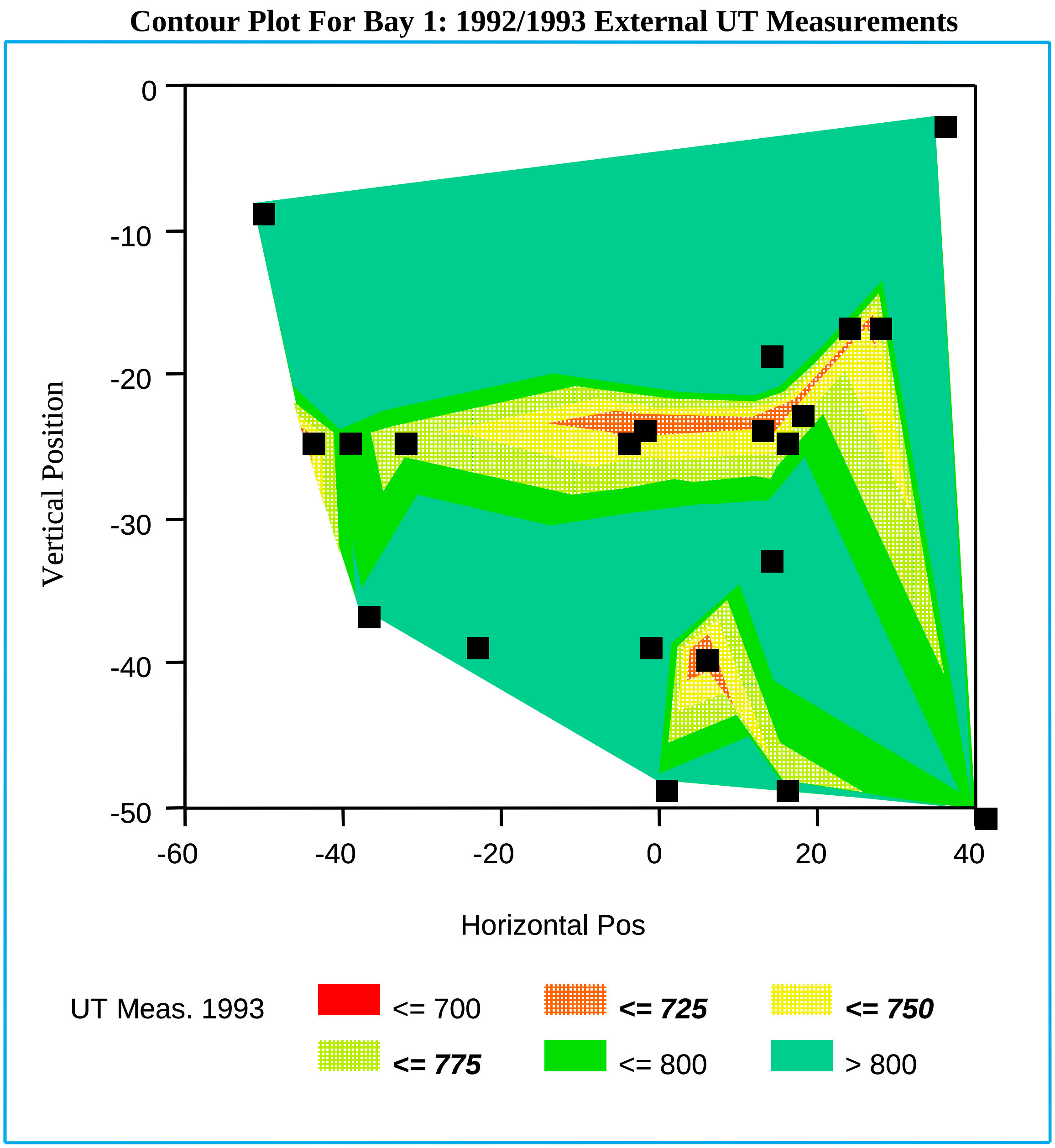


Figure 3

Bay 1 Remaining Wall thickness
External UT Measurements 2006

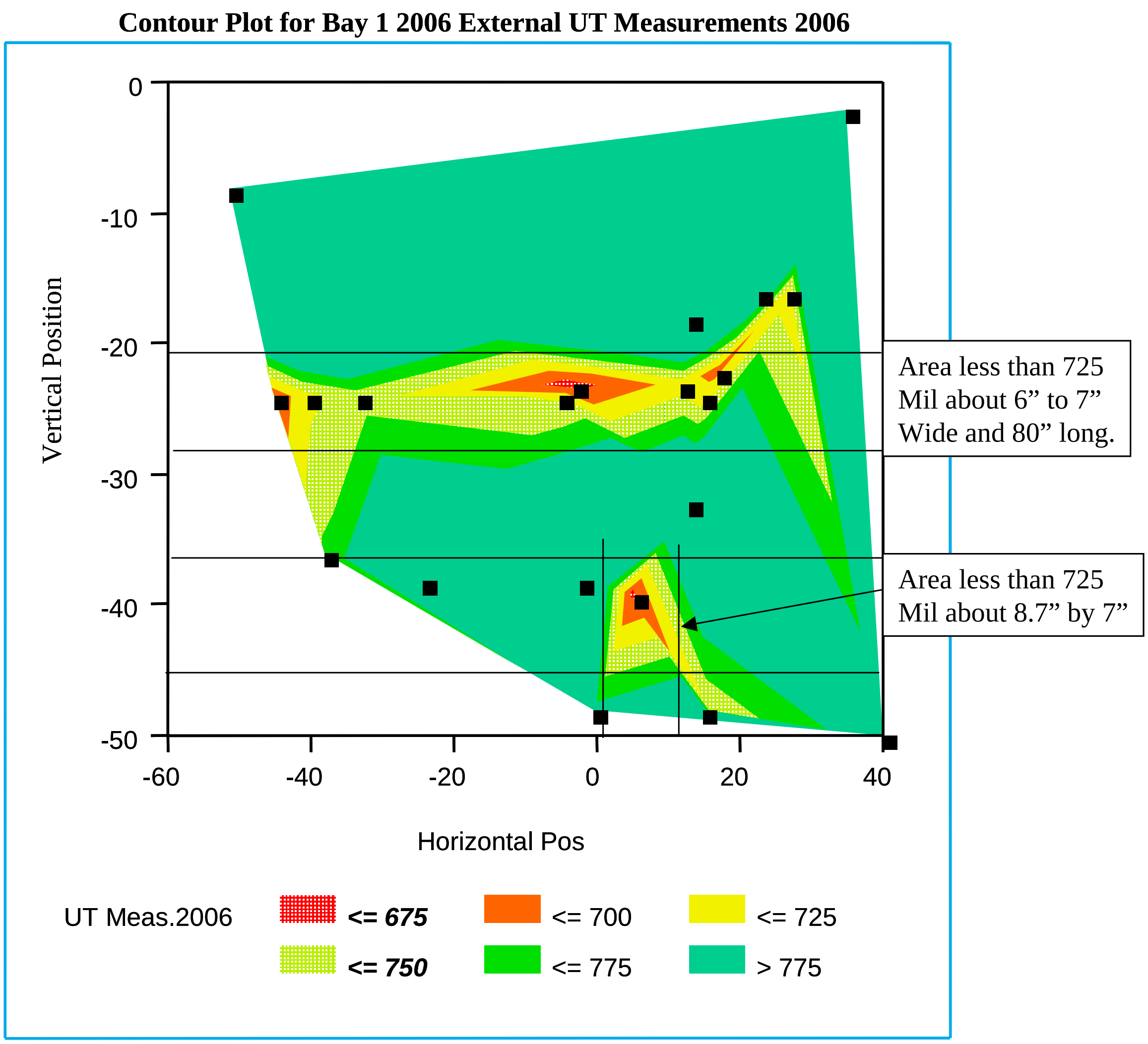


Figure 4

Bay 13 Remaining Wall Thickness
External UT Measurements 1992/1993

Contour Plot for Bay 13 19921993 External UT Data

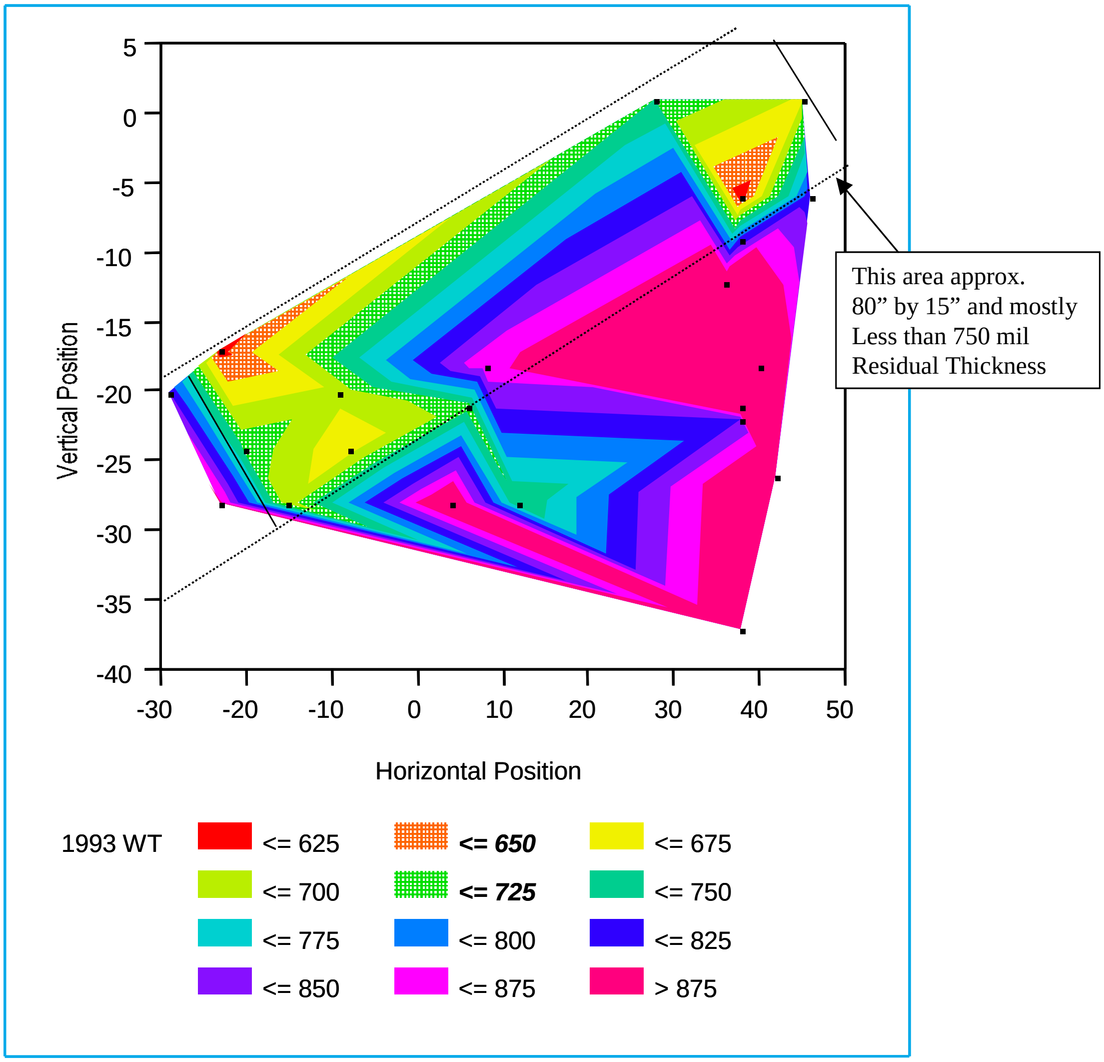
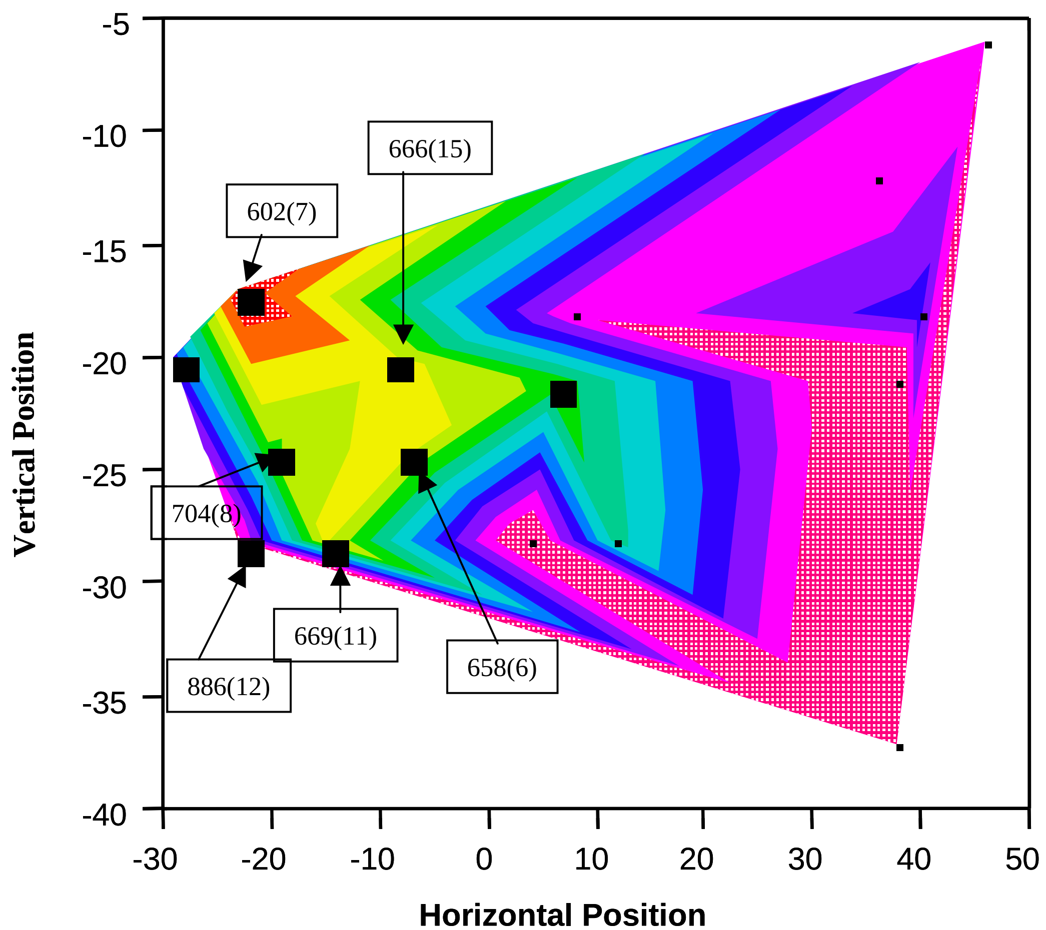


Figure 5

Bay 13 Remaining Wall Thickness
External UT Measurements 2006

Bay 13 Contour Plot 2006 UT Data



Numbers are residual wall thickness and (measurement ID)

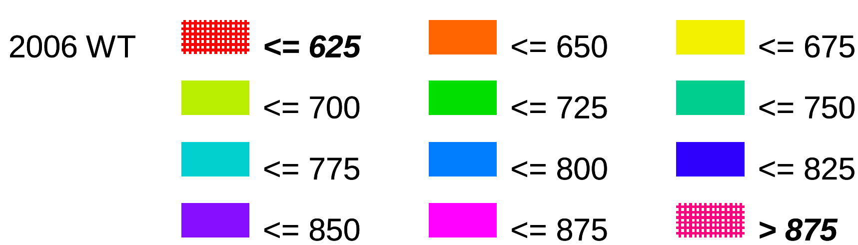


Figure 6

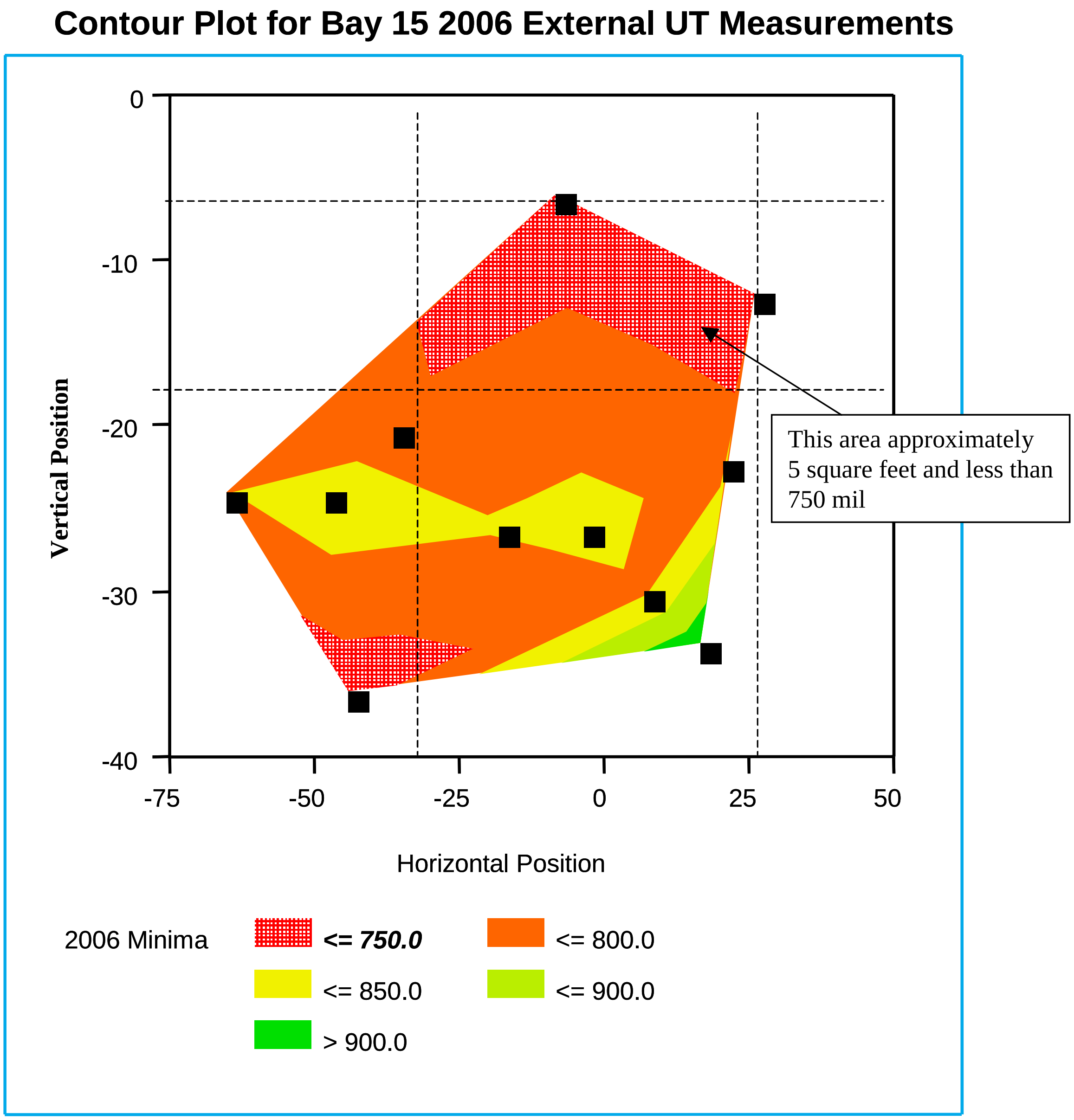

Contour Plot for Bay 15 2006 External UT Measurements
0
-10
-20
-30
-40
Vertical Position
-75
-50
-25
0
25
50
Horizontal Position
This area approximately
5 square feet and less than
750 mil
2006 Minima
<= 750.0
<= 800.0
<= 850.0
<= 900.0
> 900.0

Figure 7

Contour Plot for External UT 1992 Data Bay 11