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INTERIM CHANGE NOTICE (ICN)

Page 1 of 32

A. Document No.: PNNL-13667 **Revision No.:** ~~November 2000~~ 1
Document Title: Groundwater Monitoring Plan for the Hanford Site 216-B-3 Pond RCRA Facility

Document's Original Author: D. B. Barnett, R. M. Smith, and C. J. Chou

Effective Date of ICN: 3/31/02

Change Requested By: D. B. Barnett

B. Action:
Make changes in the 216-B-3 Pond system groundwater monitoring plan, as described below in Section D. Attach this ICN to the front of the document, just before the title page.

C. Effect of Change:
The groundwater monitoring network, constituent list, statistical analysis method, and reporting procedures are changed in accordance with descriptions in the attached, revised sections.

D. Reason for Change/Description of Change:
Reason for Change: Update groundwater monitoring plan at the 216-B-3 Pond system (PNNL-13667) and document revisions agreed upon with the Washington State Department of Ecology concerning well network, constituent list, statistical analysis, and reporting procedures.
Description of Change:
(1) Mark through Summary with a single line and refer to the attached Summary.
(2) Mark through Section 1.0 and 1.1 with a single line and refer to the attached Section 1.0 and 1.1.
(3) Mark through Section 5.0 and 5.1 with a single line and refer to the attached Section 5.0 and 5.1.
(4) Mark through Section 5.3 and 5.4 with a single line and refer to the attached Section 5.3 and 5.4
(5) Mark through Section 5.9 with a single line and refer to the attached Section 5.9
(6) Mark through Section 5.10 with a single line and refer to the attached Section 5.10
(7) Add additional references to the reference list, add attached diagram for well 699-43-43 to Appendix C, and add the attached Appendix D.

E. Document Management Decisions:
This ICN is large because it updates the interim plan with new analysis methods approved by Ecology. This document is issued instead of revising the interim plan (PNNL-13667) to provide the necessary information for the ongoing work while the final plan is in preparation. The final plan will include these newly approved methods.

F. Approval Signatures
(Please Sign and Date)
Process Quality Department T. G. Walker Thomas G Walker 3/7/02

Type of Change: (Check one):
___ Minor _X_ Major

Approval Authority: S. P. Luttrell [signature] Date: 3/04/02

Other Approvals: C. J. Chou (Technical) V G Johnson / for Charissa Chou Date: 3/05/02

M. J. Hartman (Technical Review) Mary J Hartman Date: 27 Feb 02

D. B. Barnett (Author) [signature] Date: 2/26/02

Summary

The 216-B-3 Pond was a series of ponds used for disposal of liquid effluent from past Hanford production facilities. In operation since 1945, the B Pond System has been a RCRA facility since 1986, with RCRA interim-status groundwater monitoring in place since 1988. In 1994 the expansion ponds of the facility were clean-closed, leaving only the main pond and a portion of the 216-B-3-3 ditch as the currently regulated facility.

In 1990, groundwater monitoring at B Pond was elevated from "detection" to assessment status because total organic halides and total organic carbon were found to exceed critical mean values in two wells. Groundwater quality assessment, which ended in 1996, failed to find any specific hazardous waste contaminant that could have accounted for the isolated occurrences of elevated total organic halides and total organic carbon. Hence, the facility was subsequently returned to detection-level monitoring in 1998.

Exhaustive groundwater analyses during the assessment period indicated that only two contaminants, tritium and nitrate, could be positively attributed to the B Pond System, with two others (arsenic and iodine-129) possibly originating from B Pond. Chemical and radiological analyses of soil at the main pond and 216-B-3-3 ditch has not revealed significant contamination.

Based on the observed, minor contamination in groundwater and in the soil column, three parameters were selected for site-specific, semiannual monitoring; gross alpha, gross beta, and specific conductance. Arsenic, iodine-129, nitrate, and tritium will be monitored under the aegis of Hanford site-wide monitoring to the extent possible. Total and dissolved concentrations of cadmium, lead, mercury, and silver will be analyzed annually for four years. Analysis for these metals will be discontinued after four years if no anomalous concentrations or trends are revealed.

Washington State Department of Ecology (Ecology) issued a letter[1] providing guidance for groundwater monitoring at the B Pond system because the standard indicator-parameters evaluation and accompanying interim status statistical approach is inappropriate for detecting potential B-Pond-derived contaminants in groundwater at this facility. Ecology specified in this guidance letter that certain criteria must be met prior to receiving approval of a variance from applying interim status regulations. This plan incorporates the requirements per the variance stated in Ecology's letter[1], and is in agreement with subsequent proposals with Ecology concerning monitoring network, constituent list, statistical analysis, and reporting procedures.

[1] Letter from Dib Goswami (Washington State Department of Ecology, Olympia, Washington) to Marvin Furman (U.S. Department of Energy, Richland, Washington), *Statistical Assessment for the 300 Area Resource Conservation and Recovery Act of 1976 (RCRA) Ground Water Monitoring Plan*, dated May 7, 2001

1.0 Introduction

The 216-B-3 pond system (B Pond) is a regulated wastewater disposal facility for operations in the 200 East Area of the Hanford Site (Figure 1.1). The B Pond has been a Resource Conservation and Recovery Act (RCRA) hazardous waste facility since 1986, when a RCRA (Part A) permit application was submitted to the Washington State Department of Ecology (Ecology). Groundwater monitoring has been conducted in accordance with RCRA interim status requirements since 1988, and the current detection-level monitoring program is described by Sweeney (1995). In 1998, the *Groundwater Monitoring Plan for the Hanford Site 216-B-3 Pond RCRA Facility* (Barnett and Chou 1998) was released to address the change in monitoring strategy derived from the 1997 work. The 1998 groundwater monitoring strategy included a plan for intra-well monitoring and more accurate statistical methods for evaluating groundwater data. However, inflexibility in the existing RCRA groundwater monitoring requirements administered by state regulators led to an impasse to applying the new strategy.

In May 2001, Washington State Department of Ecology (Ecology) issued a letter[1] (Ecology's letter) providing guidance for groundwater monitoring at the B Pond system because the standard indicator-parameters evaluation and accompanying interim status statistical approach is inappropriate for detecting potential B-Pond-derived contaminants in groundwater at this facility. Ecology specified in this guidance letter that certain criteria must be met prior to receiving approval of a variance from applying interim status regulations. This plan incorporates the requirements per the variance stated in Ecology's letter[1], and is in agreement with subsequent proposals with Ecology concerning monitoring network, constituent list, statistical analysis, and reporting procedures.

1.1 Objectives and Scope

The purpose of this document is to establish a groundwater monitoring program for the B Pond that will effectively address recent changes in the groundwater flow directions, and incorporate the sum of knowledge about the potential for contamination originating from the facility. This document also summarizes past and current groundwater monitoring at the B Pond and presents background information based on findings from the 1997 study, a conceptual model derived from soil and vadose zone characterization, and the most recent evaluations of groundwater hydrology and chemistry at the site. The groundwater monitoring plan in Section 5.0 supersedes the plan of Sweeney (1995).

5.0 Groundwater Monitoring Program

This section describes a groundwater monitoring program consisting of a monitoring well network, target constituents, sampling and analysis methods, and a statistical approach for data evaluation. In 1988, RCRA monitoring at B Pond began in the interim status detection level phase of groundwater monitoring. In 1990, it was placed in assessment monitoring after TOX and TOC levels in downgradient wells exceeded critical concentration limits determined from the upgradient well. After extensive assessment monitoring, it was determined that the source for the elevated TOX and TOC levels had disappeared or was indeterminate (Barnett and Teel 1997). Consequently, B Pond returned to detection level monitoring in 1998. The elements of the monitoring program presented here were modified from the existing plan (Barnett et al 2000) by incorporating recent agreements in accordance with the variance stated in Ecology's letter and agreed on proposals concerning monitoring network, constituent list, statistical analysis, and reporting at the B Pond facility with the major objectives to:

- protect human health and the environment
- comply with RCRA final status regulatory requirements (i.e., WAC 173-303-645 and 40 CFR 264 Subpart F) and agreements
- provide information for groundwater investigations and/or remediation.

RCRA groundwater monitoring efforts proposed for the B Pond will be consistent with the groundwater remediation strategy for the Hanford Site (DOE 1997a) and will be integrated with the sitewide monitoring activities where appropriate.

5.1 RCRA Interim-Status Regulatory Overview

The U.S. Environmental Protection Agency (EPA) promulgated groundwater monitoring and response standards for certain land-based interim-status facilities in 1980 (45 FR 33232, May 19, 1980), codified in 40 CFR Part 265, Subpart F. Facility owners and operators are required to sample groundwater at specified intervals and to use a statistical procedure to determine whether or not hazardous wastes from these units are contaminating groundwater.

The Hanford Site is designated as a single RCRA facility and has been assigned a single identification number for the purpose of RCRA permitting activity. Because of the complexity of the Hanford Site, most of the RCRA-regulated units are interim-status facilities and will be brought into the Hanford Facility RCRA Permit (Ecology 1994) through a permit modification process. The B Pond is currently a RCRA interim-status facility, and a closure plan will be submitted to Ecology during 2003. Although B Pond is not scheduled to advance from RCRA interim status to final status until year 2003, the site-specific indicator parameters, sampling and analysis, and statistical approach described in this plan comply with final status requirement and are in accordance with agreements per Ecology's letter and proposals submitted to Ecology concerning B Pond.

5.3 Sampling and Analysis

Table 5.1 lists the constituents to be analyzed under the B Pond facility groundwater monitoring program. Groundwater will be sampled for all constituents on a semiannual basis except the groundwater quality parameters, which will be sought annually.

Waste stream information and soil analyses (see Sections 1.5 and 1.6) indicate the possibility that some specific contaminants could impact groundwater quality at B Pond. Therefore, the B Pond facility will be monitored semiannually for specific conductance, gross alpha, and gross beta. Specific conductance will be valuable in detecting complexants and ligands that are linked to B Pond operations. Annual sampling will occur for chloride, iron, manganese, phenols, sodium, and sulfate. Additional field parameters (i.e., pH, alkalinity, dissolved oxygen, temperature, and turbidity) will be sought as indicators of sample quality and general aquifer/well environmental conditions. Total and dissolved concentrations of cadmium, lead, mercury, and silver will be analyzed annually for four years. Analysis for these metals will be discontinued after four years if no anomalous concentrations or trends are revealed.

Gross alpha and gross beta will be monitored semiannually as site-specific indicators, along with specific conductance. These indicators will be monitored to detect whether radiogenic elements from the regulated unit (especially strontium-90 and cesium-137—those having greatest potential for contributing to contamination at the B Pond) have impacted groundwater beneath the site. These indicator species can only provide an *indication* of the presence of radioactive constituents in the groundwater. They cannot identify possible specific constituent(s) that cause the degradation in groundwater quality. The specific constituents would be identified and concentration limits set should assessment or compliance monitoring be required. If additional constituents are identified, the groundwater monitoring plan will be revised in accordance with the most updated understanding of the site conditions.

Arsenic, iodine-129, nitrate, and tritium are also identified as contaminants of concern in groundwater that could be associated with B pond operations. Because these constituents are also associated with existing, widespread sitewide plumes, they will be monitored on a *regional* scale by sitewide groundwater surveillance to the extent possible, and are not included specifically as constituents for B Pond.

Table 5.1. Constituent List for the B Pond Facility

Site-Specific Indicator Parameters
Specific Conductance
Gross Alpha
Gross Beta
Groundwater Quality Parameters[(a)]
Chloride[(b)]
Iron[(c)]
Manganese[(c)]
Phenols
Sodium[(c)]
Sulfate[(b)]
Additional Chemical Parameters
Arsenic[(d)]
Nitrate[(d)]
Iodine-129[(d)]
Tritium[(d)]
Cadmium[(e)]
Lead[(e)]
Mercury[(e)]
Silver[(e)]
Field Parameters
pH
Alkalinity
Dissolved oxygen
Turbidity
Temperature

(a) Sampled annually; all others sampled semiannually.
(b) These constituents are part of a larger suite of anions provided in this analysis.
(c) These constituents are part of a larger suite of metals provided by this analysis using Inductively-coupled plasma methods.
(d) These constituents are also of Hanford sitewide concern, and are scheduled on a periodic basis in coordination with the sitewide surveillance sampling effort.
(e) To be discontinued following four years (once annually) of analyses with no anomalous concentrations or trends.

5.4 Point of Compliance and Well Network

The point of compliance (POC) is defined in WAC 173-303-645(6)(a) as a "vertical surface" located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated unit. For the B Pond, the POC will consist of the monitoring wells illustrated in Figure 5.1 (i.e., 699-43-45, 699-43-44, 699-42-42B, and 699-43-43) and Table 5.2. These wells are directly downgradient of the facility, including the regulated portion of the B-3-3 ditch. It should be noted that because data from the relatively new well 699-43-44 (drilled in September 1999) are limited, data from nearby well 699-43-43 (which is becoming dry) will be used as a historical surrogate for well 699-43-44, per agreement with Ecology. To establish the degree of data comparability between the wells, 699-43-43 is considered part of the network and is sampled as long as it remains serviceable. Most of the wells in Figure 5.1 near the B Pond (see Figure 1.2) may be used for tracking the plumes of sitewide concern; arsenic, iodine-129, nitrate, and tritium, but are not specifically part of this monitoring plan.

An effective groundwater monitoring network of wells for the B Pond must account for the peculiar groundwater flow conditions existing at this facility. To ensure interception of any potential contamination the configuration of the network will need to consider not only the degree of areal coverage, but also location of potential contamination in the vadose zone and aquifer (from main pond and B-3-3 ditch operation). More specifically, selection of wells for the revised groundwater monitoring network at the B Pond is based on:

- Areal distribution of wells in relation to the facility and the interpreted direction of groundwater flow in the confined and unconfined aquifers beneath and in the vicinity of the pond as prefaced by the conceptual model (Section 4.0). In deference to this criterion, a uniform spacing is otherwise attempted, recognizing that contaminants may potentially still be entrained in groundwater within the bounds of the facility, but with the qualification that the main pond and adjoining part of the B-3-3 ditch are the specific sources of potential contamination.

- The depth in the aquifer at which the wells are screened. As noted in Section 4.0, vertical differences in constituent concentrations are observed and must be accounted for qualitatively in network design. Wells are needed to monitor the confined aquifer in unit 9A as well as in the unconfined aquifer west and south of the pond.

- The expected life of the well, based on the water level and rate of decline; as discussed in Section 2.0, some wells have very limited projected life. Wells in the revised network are selected to optimize the balance between well life and the other attributes described here except for 699-43-43, which is discussed for reasons provided earlier.

Using these guidelines, the revised groundwater monitoring network for the B Pond was derived, as shown in Figure 5.1. The proposed monitoring network for the B Pond consists of five wells; the construction details and lithologic logs of these wells are presented in Appendix C. The complex orientation of geologic strata beneath B Pond, and the unconfined and confined aquifers, makes well 699-44-39B the most logical selection for an upgradient monitoring location. This well is completed in Ringold unit 9A, and is currently upgradient of the B Pond and the selected downgradient wells. Although groundwater flows under confined conditions in the vicinity of well 699-44-39B, this water discharges to the unconfined portion of the aquifer southwest and south of the main pond and B-3-3 ditch.

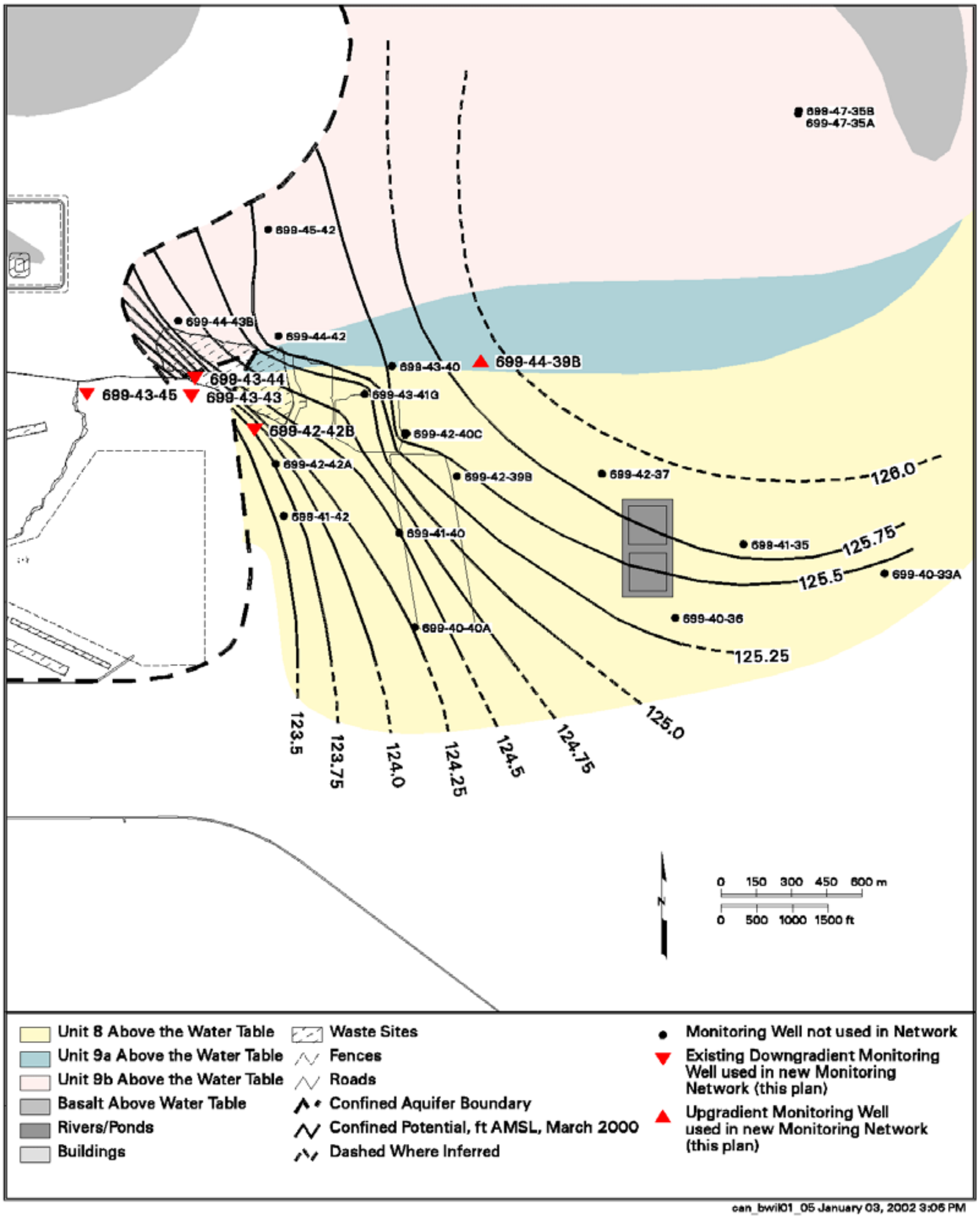


Figure 5.1. Location of Monitoring Wells in the Revised B Pond Network

Table 5.2. Revised B Pond Groundwater Monitoring Well Network

Well	Date of Construction	Units Monitored	Estimated Years of Service Left[a]
699-44-39B (upgradient)	September 1992	Ringold unit A—completed below water table	9
699-42-42B	August 1988	Ringold unit A—completed below water table	20
699-43-43[b]	September 1988	Hanford formation—completed at water table	Less than one year
699-43-44	September 1999	Hanford formation—completed at water table	New well—no estimate yet available
699-43-45	May 1989	Hanford formation—completed at water table	8.4

(a) As calculated in Table B.1, Appendix B.

(b) Will be used as a historical surrogate for 699-43-44 per agreement with Ecology. To establish the degree of data comparability between the wells, this well is considered part of the network and sampled as long as it remains serviceable.

5.9 Statistical Evaluation

The B Pond system has been monitored as a RCRA interim-status facility since 1988. In the past, sampling procedures and statistical evaluation methods were based on 40 CFR 265 Subpart F (and by reference of WAC 173-303-400). These interim-status regulations require the use of a t-test method that compares mean concentrations of the four general contamination indicator parameters (i.e., specific conductance, pH, total organic carbon, and total organic halogen) between one upgradient and nine downgradient wells (system previously in place) for the B Pond system on the basis of four replicate measurements during each sampling event (EPA 1989b). The required sampling and statistical method are flawed (see Davis and McNichols 1994 and Cameron 1996). After numerous discussions and lengthy negotiations with Ecology, the proposal presented by U.S. Department of Energy requesting a "variance" from applying interim-status regulations at B-Pond was finally approved in May 2001. However, prior to receiving approval of a variance, conditions specified in Ecology's letter must be met. Ecology's letter provides a path to more efficient and cost effective monitoring at B Pond as described below:

- Only site-specific parameters (gross alpha, gross beta and specific conductance) will be subject to statistical evaluations on a semiannual basis.
- The combined Shewhart-CUSUM control chart method will be applied to the three site specific-parameters. The appropriate baseline period for the data will be identified and baseline data evaluated. Outliers will be addressed to avoid bias in the statistical analysis.
- American Society for Testing and Materials (ASTM) guidance (1996) will be used to evaluate non-detect results and outliers.
- Normal probability plots will be used to verify normal distribution of data.
- Input parameter values (k= the amount of increased shift in the mean concentration to be detected, SCL = Shewhart control limit, and CCL or h = CUSUM control limit) will be proposed and submitted to Ecology for approval prior to implementation of the groundwater monitoring plan. Power curves illustrating probabilities for false positive and false negative will be submitted.

This section describes the statistical evaluation objectives, rationale for using the combined Shewhart-CUSUM control method, and baseline summary statistics for the site-specific parameters (i.e., specific conductance, gross alpha, and gross beta) in each of the B Pond system network wells (i.e., one upgradient well 699-44-39B and four down gradient wells 699-43-45, 699-43-44, 699-42-42B, and 699-43-43) in accordance with Ecology guidance. Input parameter values (k, SCL, h or CCL) that lead to the final selection of control limits for each of the site-specific parameters for wells in the network as well as associated power curves will be proposedand submitted to Ecology in FY 02. Once agreement has been reached with Ecology concerning the values for the input parameters, resulting control limits will be incorporated into a final status groundwater monitoring plan and is expected to be implemented later in FY 02.

5.9.1 Objectives of Statistical Evaluation

The goal of a RCRA final status detection-monitoring program [WAC 173-303-645(9)] is to determine whether the regulated unit has adversely affected the groundwater quality in the uppermost aquifer beneath the site. This is accomplished by testing for statistically significant changes in concentrations of constituents of interest in a downgradient well relative to baseline values. In the B Pond case, the objectives of the proposed statistical evaluation method are:

1. To keep the site-wide false-positive rate (across all constituents and wells being tested) at an acceptably low level.

2. To have adequate statistical power to detect real contamination when it occurs.

To achieve the goal of lowering the site-wide false-positive rate, the number of tested constituents is limited to the most useful indicators (EPA 1992, page 62; Gibbons 1994, page 16); therefore, only the three site-specific parameters (specific conductance, gross alpha, and gross beta) will be subject to statistical evaluation for the B Pond system. Another strategy to lower the overall false-positive rate is to perform verification sampling to determine whether the statistically significant changes between baseline and compliance-point data is an artifact caused by an error in sampling, analysis, or statistical evaluation.

Another goal of the statistical method applied is to maintain adequate statistical power for detecting real contamination. The power of a test depends on several factors that include the baseline sample size, the type of statistical test proposed, and the number of comparisons (i.e., the false-positive rate). It is judged that the statistical goals will be best achieved by the combined Shewhart-CUSUM control chart method for reasons as discussed below.

5.9.2 Rationale for Using Shewhart-CUSUM Control Chart Method

In accordance with WAC 173-303-645(8)(h), acceptable statistical methodology includes analysis of variance (ANOVA), tolerance intervals, prediction intervals, control charts, test of proportions, or other statistical methods approved by Ecology. The type of monitoring, the nature of the data, the proportions of non-detects, and spatial and temporal variations are some of the important factors to be considered in the selection of appropriate statistical methods. One of the alternative statistical tests, allowable under final status regulations WAC 173-303-645(8)(h), is the use of a combined Shewhart-CUSUM control chart approach, first referenced by Westgard et al (1977) and further developed by Lucas (1982). This method is also discussed in a groundwater context by Starks (1989), Gibbons (1994), and ASTM (1996) and first adopted into EPA guidance in 1989 (EPA 1989, 1992). There are several advantages in applying the control chart procedure:

- This method can be implemented with a single observation at any monitoring event (i.e., this method is efficient).

- This method could be applied to monitoring each well individually and yet maintain desired site-wide false positive and false-negative error rates. That is, this method is effective. The spatial variations that adversely affect the ANOVA procedure do not play a role under the control chart procedure. [Note: Due to the elimination of spatial variability, the uncertainty in measured concentrations is decreased making intra-well comparisons more sensitive to a real release (that is, false negatives) and false positive results (ASTM 1996)].

- The power of the control chart method could be enhanced by the combined Shewhart and CUSUM procedures. It is well known that the Shewhart procedure is sensitive to sudden shifts and the CUSUM procedure is sensitive to gradual changes in the mean concentrations. A combined Shewhart and CUSUM procedure, therefore, is well designed to detect both types of changes.

Statisticians at Washington State University (WSU) evaluated the efficacy of this method for monitoring groundwater quality on behalf of Ecology (WSU 1999) in 1999 using B Pond monitoring data. In their report, WSU also endorsed the control chart method of monitoring groundwater quality.

5.9.3 Shewhart-CUSUM Control Chart Procedures

The combined Shewhart–CUSUM method can be implemented following a baseline of eight or more independent sampling periods for a given well (ASTM 1996). The method assumes that the groundwater baseline data and future observations will be independent and normally distributed. The most important assumption is that the data are independent. The assumption of normality can usually be met by log-transforming the data or by other Box-Cox transformations. The method is more fully discussed in Lucas (1982), Starks (1989), Gibbons (1994), and ASTM (1996).

The method is a sequential testing procedure to test for an upward shift in the mean concentration of a constituent of interest. The Shewhart portion of the test checks for any sudden upward shift in groundwater quality parameters based on a single observation, while the CUSUM checks for any gradually increasing trend in the groundwater quality parameters. The procedure can be implemented as follows: Let x'_i be a series of independent baseline observations i = 1,…., b (b = 8). Let x_i be a series of future monitoring measurements i = 1, 2, 3….. .

Then, using the baseline data, the following steps are applied:

1) First determine if the x'_i can be assumed to follow a normal distribution with mean μ and standard deviation σ. If not, transform the x'_i using the appropriate Box-Cox transformation and work with the transformed data.

2) Next use the baseline data to compute the estimates

$$\bar{x}' = \sum_{i=1}^{b} x'_i/\text{b for } \mu \text{ and } s' = \sqrt{\sum_{i=1}^{b} (x'_i - \bar{x}')^2 /(b-1)} \text{ for } \sigma.$$

3) Determine the upper Shewhart control limit (SCL) for the procedure by calculating $SCL = \bar{x}' + z_s s'$ where z_s is a percentile from the standard normal distribution used to set the false negative and false positive values of the Shewhart control limit. The value of z_s that is most often suggested for groundwater use is 4.5 by Lucas (1982), Starks (1989), EPA (1989), and ASTM (1996). Other values may also be used, depending on the sampling scheme used and whether verification sampling is used to modify the false positive and false negative error rates.

4) Determine the upper CUSUM control limit (CCL), with $CCL = \bar{x}' + z_c s'$. The value of z_c suggested by Lucas (1982), Starks (1988), and EPA (1989) is $z_c = 5$. This value can also be adjusted to reach desired false negative and false positive error rates. In practice setting $z_c = z_s = 4.5$ results in a single limit with no compromise in leak detection capabilities (ASTM 1996).

5) Determine the amount of increased shift in the mean of the water quality parameter of interest to detect an upward trend. This value is referenced as k and is usually measured in σ units of the water quality parameter. Lucas (1982), Starks (1988), and EPA (1989) suggest a value of k = 1 if there are less than 12 baseline observations; and a value of k = 0.75 if there are 12 or more baseline observations.

Using the monitoring data after the baseline measurements have been established:

6) Compute the CUSUM statistic as $S_i = \max\{0, (x_i - ks') + S_{i-1}s'\}$ as each new monitoring measurement, x_i becomes available, where i = 1,2,3,….., max{a, b} is the maximum of a and b, and $S_0 = 0$.

7) As each new monitoring measurement becomes available, compute the Shewhart and CUSUM tests; a verification sampling will be conducted if either $x_i \geq$ SCL or $S_i \geq$ CCL. A well is declared to be out of control only if the verification result also exceeds the SCL or the CCL. If both $x_i <$ SCL and $S_i <$ CCL, then continue monitoring.

8) As monitoring continues and the process is shown to be in control, the baseline mean and standard deviation should be updated periodically (e.g., every year or two) to incorporate these new data. This updating process should continue for the life of the monitoring program.

If resampling is implemented during the monitoring, the analytical result from the resample is substituted into the above formulas for the original value obtained, and the CUSUM statistic is updated. Note in the above combined test that the Shewhart portion of the test will quickly detect extremely large deviations from the baseline period. The CUSUM portion of the combined test is sequential; thus, a small shift in the mean concentration over the baseline period will slowly aggregate in the CUSUM statistic and eventually cause the test to exceed the CUSUM control limit.

5.9.4 Evaluation of Detection History and Goodness-of-fit Test Results

In order to arrive at appropriate control limits, the detection history for each constituent of concern at each well must first be evaluated (ASTM 1996). Historical measurements subsequent to January 1995 were judged to be most relevant for data evaluation purposes because the changes in condition rendered prior data no longer representative. For example, in April 1994, discharges to the main pond ceased, and all effluents were rerouted to the 3C expansion pond via a pipeline. Also, during 1994, the main pond and the 216-B-3-3 ditch (B-3-3 ditch) were filled with clean soil, and all vegetation was removed from the perimeter and included with the fill soil, as part of interim stabilization activities. Termination of discharge to the B Pond system caused groundwater flow direction changes.

Detection status for the site-specific parameters is presented in Table 5.3 using data obtained from January 1995 through June 2001. It can be seen from Table 5.3 that the detection frequencies for the three site-specific parameters are greater than 25%. Therefore, the use of nonparametric prediction limit which equals the maximum quantified value as the control limit is not necessary (see ASTM 1996, page 6). In addition, the laboratory provided actual concentrations even when gross alpha and gross beta data were below background signals (i.e., non-detect). Therefore, for statistical evaluation purposes, actual concentrations provided by the laboratory were used.

One of the assumptions for the combined Shewhart-CUSUM control chart approach is that the data are normally distributed. One simple and easy way to evaluate whether a sample can reasonably be regarded as having come from a normal distribution is through the use of a normal probability plot. The plot is constructed so that if data points fall on a straight line, then these data can be assumed to be from a population with a normal distribution. Following Ecology guidance (Ecology 2001), normal probability plots were generated for each of the site-specific parameters in each B Pond system well. The plots are presented in Appendix D. Additionally, statistical test for evaluating whether or not the data follow a specified distribution (called the goodness-of-fit tests) is also used. A recommended test is the Shapiro-Wilk test for normality of the data (Shapiro and Wilk 1965). It is considered to be one of the very best tests of normality available (Miller, 1986; Mandansky, 1988). The Shapiro-Wilk test statistic (W) will tend to be large when a probability plot of the data indicates a nearly straight line (i.e., normal distribution). Only when the plotted data show significant departure from normality the test statistic will be small. Hence if the computed value of W is less than the critical value W_α for a prechosen value of α (e.g., $\alpha = 5\%$) shown in statistical table, the hypothesis of normality is rejected. The Shapiro-Wilk test of normality can be used for sample sizes up to 50. Procedures are provided in EPA (1992, pages 9-12), Shapiro (1980, pages 20-24), and Conover (1980, pages363-366). The Wilk-Shapiro test results for the B pond system are also presented in Table 5.3. The normal distribution is a reasonable assumption except for gross beta in 699-42-42B, which is better represented by a log-normal distribution (Table 5.3).

5.9.5 Baseline Summary Statistics

The B Pond system was operated to receive effluent discharges containing radioactive, dangerous waste, and cooling water from the PUREX Plant, B-Plant, and other 200 Area facilities between 1945 and 1997. The B Pond system has been a RCRA facility since 1986, with RCRA interim-status groundwater monitoring in place since 1988. In 1994, discharges were diverted from the main pond, where the greatest potential for contamination was thought to reside, to the 3C expansion pond. Also, during 1994, the main pond and the B-216-B-3-3 ditch (B-3-3 ditch) were filled with clean soil, and all vegetation was removed from the perimeter and included with the fill soil, as part of interim stabilization activities. In 1997, all discharges to the pond system were discontinued. Termination of discharge to the B Pond system caused groundwater flow direction changes. Time versus concentration plots for specific conductance, gross alpha, and gross beta using monitoring data obtained subsequent to January 1995 are shown in Figures 5.2 through 5.4. It is obvious from these figures that there are insufficient data (less than the minimum required 8 data points) from well 699-43-44 for all site-specific parameters of concern. In addition, gross alpha and gross beta data from well 699-43-43 are not only sparse but also old (only 3 data points that were analyzed prior to October 1995).

Table 5.3. Detection Status and Results of Shapiro-Wilk Test for the B Pond System Site-Specific Parameters

Network	699-42-42B	699-43-43	699-43-44	699-43-45	699-44-39B
Specific Conductance					
Time Period	1/95 - 6/01	1/95 – 6/01	9/99 – 6/01	1/95 – 6/01	1/95 –6/01
N[a]	18	18	4[b]	27	19
Detected	18	18	4[b]	27	19
Non-Detect	0	0	0	0	0
W-test Statistic	0.9525	0.9475	NC	0.9752	0.9261
Critical Value	0.897	0.897	NC	0.923	0.901
Distribution	Normal	Normal	NC	Normal	Normal
Gross Alpha					
Time Period	1/95 - 6/01	1/95 – 7/95	9/99 – 6/01	1/95 – 1/01	1/95 –6/01
N	18	3	6	16	17
Detected	16	0	4	6	12
Non-Detect	2	3	2	10	5
W-test Statistic	0.9547	NC	0.9087	0.9204	0.9385
Critical Value	0.897	NC	0.788	0.887	0.892
Distribution	Normal	NC	Normal	Normal	Normal
Gross Beta					
Time Period	1/95 - 6/01	1/95 – 7/95	9/99 – 6/01	1/95 – 1/01	1/95 –6/01
N	18	3	6	16	17
Detected	17	3	5	16	15
Non-Detect	1	0	1	0	2
W-test Statistic	0.9293[c]	NC	0.9308	0.9423	0.9043
Critical Value	0.897	NC	0.788	0.887	0.892
Distribution	Log-Normal	NC	Normal	Normal	Normal

[a]n is the sample size (number of samples) in the time period under evaluation.
[b]Outlier(s) excluded.
[c]Calculated based on log (natural) transformed data because the assumption of a normal distribution was rejected.
NC = not calculated due to insufficient sample size.

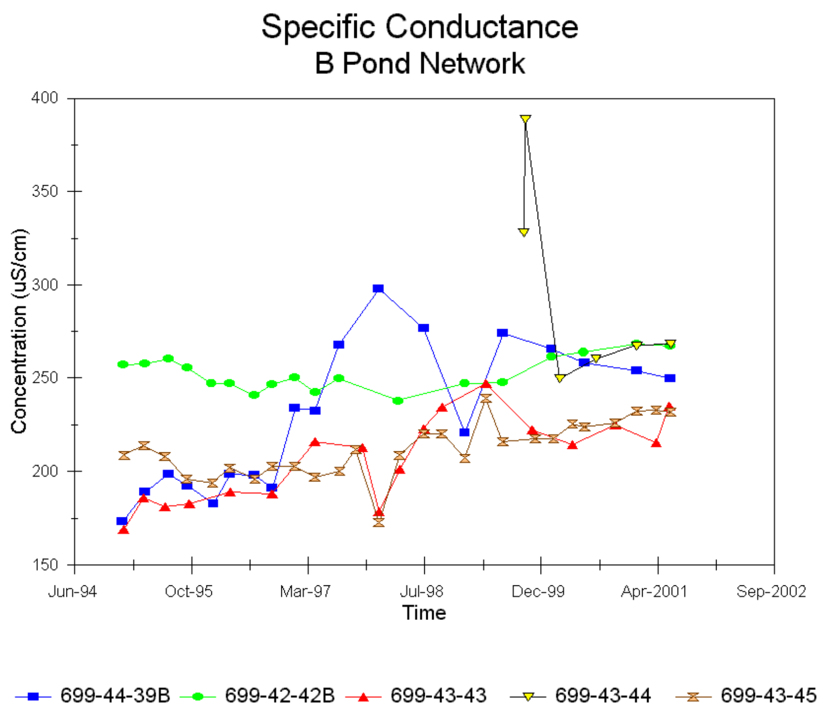


Figure 5.2. Specific Conductance Time Versus Concentration Plot

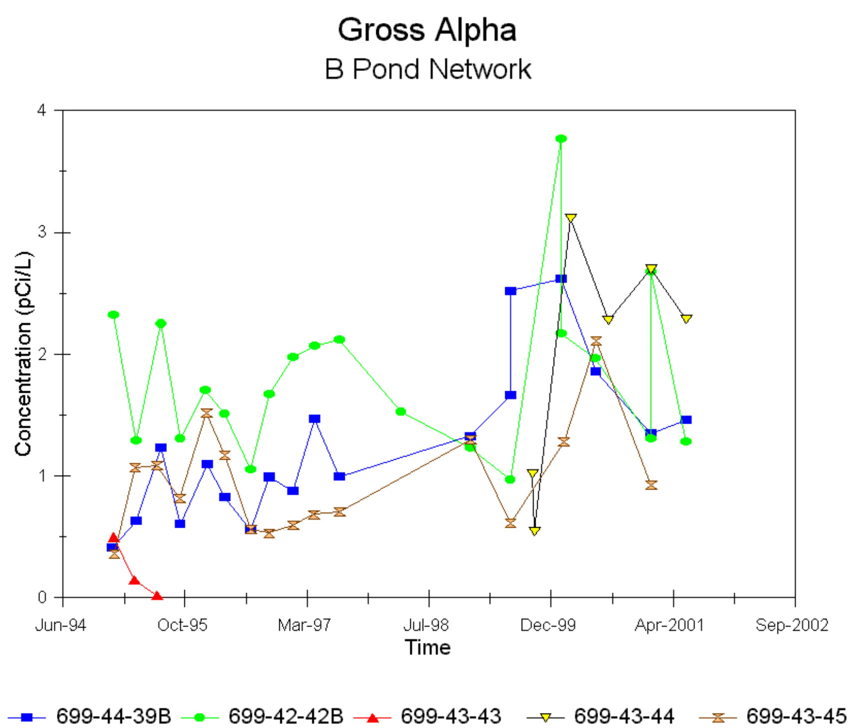


Figure 5.3. Gross Alpha Time Versus Concentration Plot

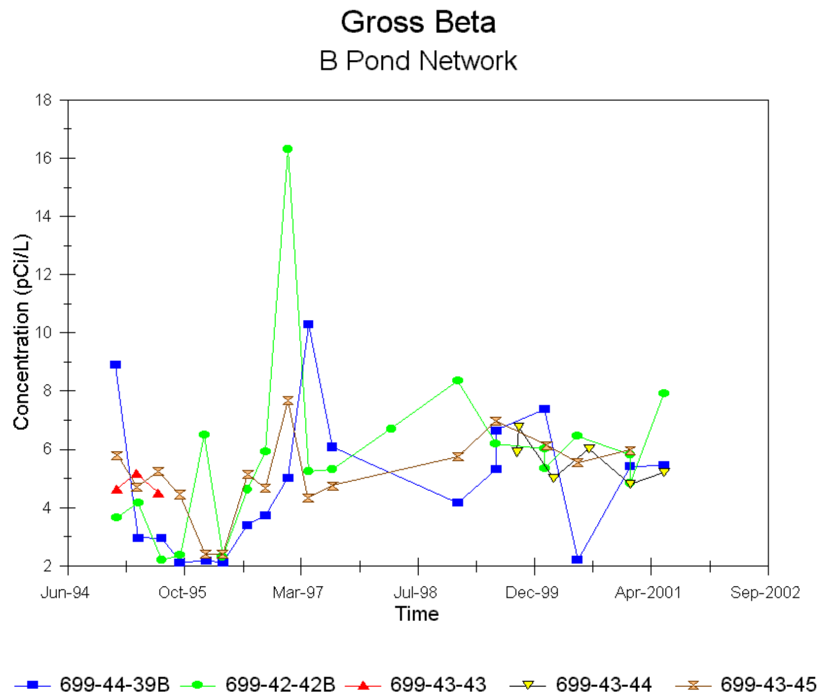


Figure 5.4. Gross Beta Time Versus Concentration Plot

Following guidance letter[1] it is judged that the most recent 8 sampling events would provide the most representative baseline period for deriving the combined Shewhart-CUSUM control limits with which future sampling data are compared. Tables 5.4 to 5.6 provide respective baseline periods and the summary statistics for the three site-specific parameters for the B Pond system network wells where sufficient data exist. It should noted that even though there are only six baseline data points of gross alpha and gross beta for well 699-43-44 (drilled in calendar year 1999), baseline summary statistics were calculated and presented in Tables 5.5 and 5.6, respectively. These statistics are in fair agreement with the other wells that have eight samples. We propose to use these statistics during the interim period until the minimum required eight data points become available. At that time the baseline summary statistics will be updated and revised.

Table 5.4. Specific Conductance Baseline Periods and Summary Statistics for the B Pond System Wells

	699-42-42B (µS/cm)	699-43-44 (µS/cm)	699-43-45 (µS/cm)	699-44-39B (µS/cm)
Baseline Period	7/27/97 – /12/01	7/21/98 – 6/7/01	11/10/99 – 6/13/01	1/9/98 – 6/12/01
Number of Samples	8	8	8	8
Mean ($\bar{x}$)	255.50	227.16	226.03	262.22
Standard Deviation (s)	11.23	11.08	6.23	22.55
CV[a] (%)	4.4	4.9	2.8	8.6
Fitted Distribution[b]	Normal	Normal	Normal	Normal

[a]Coefficient of variation = (s/$\bar{x}$) * 100
[b]Based on goodness-of-fit test results shown in Table 5.3.

Table 5.5. Gross Alpha Baseline Periods, Summary Statistics, and Various Control Limits for the B Pond System Wells

	699-42-42B (pCi/L)	699-43-44 (pCi/L)	699-43-45 (pCi/L)	699-44-39B (pCi/L)
Baseline Period	7/22/97 –6/12/01	9/22/99 – 6/12/01	1/13/97 – 1/18/01	4/10/97 – 6/12/01
Number of Samples	8	6[a]	8	8
Mean ($\bar{x}$)	1.76	1.99	1.03	1.65
Standard Deviation (s)	0.64	1.00	0.52	0.52
CV[b] (%)	36.5	50.0	50.6	31.3
Fitted Distribution[c]	Normal	Normal	Normal	Normal

[a]Because the data points from this relatively new well are limited, the calculated control limits will be revised when 8 data points are available.
[b]Coefficient of variation = (s/$\bar{x}$) * 100
[c]Based on goodness-of-fit test results shown in Table 5.3.

Table 5.6. Gross Beta Baseline Periods, Summary Statistics, and Various Control Limits for the B Pond System Wells

	699-42-42B (pCi/L)	699-43-44 (pCi/L)	699-43-45 (pCi/L)	699-44-39B (pCi/L)
Baseline Period	7/22/97 – 6/12/01	9/22/99 – 6/12/01	1/13/97 – 1/18/01	4/10/97 – 6/12/01
Number of Samples	8	6[a]	8	8
Mean ($\bar{x}$)	6.51	5.63	5.91	5.88
Standard Deviation (s)	1.23	0.74	1.09	2.35
CV[b] (%)	18.9	13.1	18.4	40.0
Fitted Distribution[c]	Log-Normal	Normal	Normal	Normal

[a]Because the data points from this relatively new well are limited, the calculated control limits will be revised when 8 data points are available.
[b]Coefficient of variation = $(s/\bar{x}) * 100$
[c]Based on goodness-of-fit test results shown in Table 5.3.

5.10 Reporting

Groundwater chemistry and water level data are reviewed at least semiannually and are available in HEIS. The results of the statistical evaluation will be submitted to Ecology in RCRA quarterly reports and in the annual groundwater monitoring report of the Hanford Site Groundwater Monitoring Project (e.g., Hartman et al 2001). In addition, groundwater analytical and hydrologic data from nearby facilities such as Liquid Effluent Retention Basins, Treated Effluent Disposal Facility, and the 216-A-29 Ditch, will be examined for results that may lend understanding to the B Pond hydrogeologic system and will be discussed in the Hanford Site annual groundwater report, as appropriate. This discussion will be accompanied by recommendations for modifications of the well network and/or constituent list, as necessary.

If groundwater monitoring data indicates that there is a statistically significant evidence of contamination (using method as described in Section 5.9) for one or more of the constituent of concern (i.e., specific conductance, gross alpha, gross beta) at any monitoring well at the compliance point, Ecology will be notified within 7 days of the finding indicating which indicator(s) have shown statistically significant evidence of contamination. Develop and submit to Ecology a groundwater quality assessment plan within 15 days after the notification, or within the time agreed by Ecology in writing as long as the B Pond system remains as an interim-status facility. Otherwise, an application for a permit modification to establish a compliance-monitoring program will be submitted to Ecology in 90 days or within the time agreed by Ecology in writing, if the B Pond system is brought into the Hanford Facility RCRA Permit (Ecology 1994) and is subject to final status groundwater monitoring requirements.

6.0 Additional References

Ecology. 1994. *Dangerous Waste Portion of the Resource Conservation and Recovery Act Permit for the Treatment, Storage, and Disposal of Dangerous Waste*, as amended, Permit Number 7890008967, effective September 28, 1994, Olympia, Washington.

Hartman, M. J., L. F. Morasch, and W. D. Webber (eds.). 2001. *Hanford Site Groundwater Monitoring for Fiscal Year 2000*. PNNL-12086, Pacific Northwest National Laboratory, Richland, Washington.

Mandansky, A. 1988. *Prescriptions for Working Statisticians*. Springer-Verlag, New York, New York.

Miller, R. G., Jr. 1986. *Beyond ANOVA, Basics of Applied Statistics*. John Wiley & Sons, New York. New York.

Shapiro, S. S. 1980. "How to Test Normality and Other Distributional Assumptions." In *ASQC Basic References in Quality Control: Statistical Techniques*, Vol. 3., ed. E. J. Dudewicz. American Society of Quality Control, Milwaukee, Wisconsin.

Shapiro, S. S. and M. B. Wilk. 1965. "An Analysis of Variance Test for Normality (complete samples)." *Biometrika* **52**:591-611.

WSU. 1999. *Report on Statistical Analysis for B-Pond Groundwater Monitoring Program.* V. Krishna Jandhyala and Hao Zhang, Program in Statistics, Washington State University, Pullman, Washington.

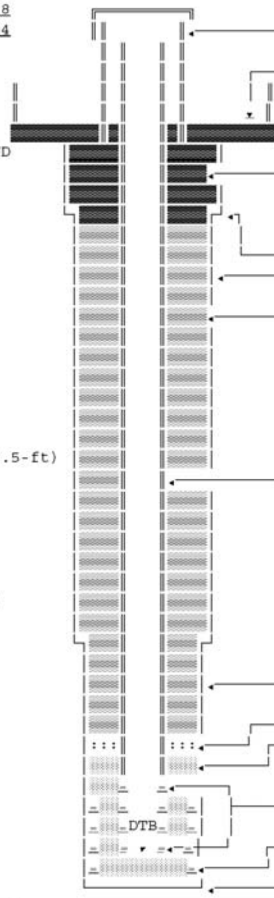
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel & Hard tool	WELL NUMBER: 699-43-43 A5179 TEMPORARY WELL NO: BP-8
Drilling Fluid Used: 200E Area Water	Additives Used: Not documented	Hanford Coordinates: N/S N 42,942.4 E/W W 43,184.4
Driller's Name: Ludtke	WA State Lic Nr: Not documented	State Coordinates: N 448,133.4 E 2,252,030.5
Drilling Company: Onwego Drilling Co	Company Location: Kennewick, WA	Start Card #: Not documented T____ R____ S________
Date Started: 02Aug88	Date Complete: 23Sep88	Elevation Ground surface: 576.00-ft Brass cap

Depth to water: 159.3-ft 07Oct88
(Ground surface) 162.0-ft 22Jul94

GENERALIZED Geologist's
STRATIGRAPHY Log

0..5: Slightly silty gravelly SAND
5..10: Silty sandy GRAVEL
10..35: SAND (medium)
35..40: SAND (medium to fine)
40..45: SAND (fine)
45..60: SAND (medium)
60..80: Gravelly SAND
80..85: SAND (fine)
85..90: Slightly gravelly, slighlty silty SAND
90..95: Slighlty gravelly SAND
95..105: SAND (medium)
105..120: Sandy GRAVEL
120..125: Gravelly SAND
125..130: (Sandy GRAVEL - Basalt BOULDER 124..138.5-ft)
130..135: SAND (medium)
135..140: Slightly gravelly SAND
140..145: Gravelly SAND
145..165: Sandy GRAVEL
165..170: Gravelly SAND
170..175: Silty sandy GRAVEL (Top of Ringold 173-ft)
175..180: Sandy GRAVEL
180 : Slightly gravelly SAND



Elevation of reference point: [579.37-ft] (top of casing)
Height of reference point above ground surface [3.4-ft]
Depth of surface seal [2.0..18.0-ft]
Type of surface seal:
Cement grout to 18.0-ft
4 x 4-ft x 4-in concrete pad extends 2.0-ft into annulus
13-in nominal hole, 0..15.5-ft
11-in nominal hole, 15.5..126.0-ft
Granular bentonite, 18.0..147.5-ft
4-in ID T304 stainless steel casing, +ND..156.8-ft
9-in nominal hole, 126.0..180.0-ft
Bentonite pellets, 147.5..152.0-ft
Silica sand pack, 152.0..180.0-ft, 20..40-mesh
4-in T304 stainless steel screen, 156.8..177.4-ft, #10-slot
8-in T304 SS telescoping screen, 159.5..179.5-ft, #20-slot
Borehole drilled depth: [180.0-ft]

DRILLER'S NOTE:
Added basalt gravel and rocks to hole when drilling basalt boulder at 124-ft.

DTB=Depth to bottom, 177.4-ft, 08Apr93

Drawing By: RKL/6N43W43.ASB
Date : 22Sep94
Reference : HANFORD WELLS

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 699-43-43

```
WELL DESIGNATION    :    699-43-43
RCRA FACILITY       :    216-B-3 Pond
CERCLA UNIT         :    Not applicable
HANFORD COORDINATES :    N   42,942.4  W    43,184.4  [28Oct88-200E]
LAMBERT COORDINATES :    N  448,133    E 2,252,030    [HANCONV]
DATE DRILLED        :    Sep88
DEPTH DRILLED  (GS) :    180.0-ft
MEASURED DEPTH (GS) :    177.3-ft, 08Apr93
DEPTH TO WATER (GS) :    159.3-ft, 07Oct88
                         162.0-ft, 22Jul94
CASING DIAMETER     :    4-in, stainless steel, +NDÿ156.8-ft,
                         6-in, stainless steel, +3.4ÿ~0.5-ft
ELEV TOP CASING     :    579.37-ft,            [28Oct88-200E]
ELEV GROUND SURFACE :    576.00-ft, Brass cap  [28Oct88-200E}
PERFORATED INTERVAL :    Not applicable
SCREENED INTERVAL   :    156.8ÿ177.5-ft, 4-in stainless steel, #10-slot,
                         159.5ÿ179.5-ft, 8-in telescoping stainless steel, #20-slot
COMMENTS            :    FIELD INSPECTION, 08Apr93;
                         4 and 6-in stainless steel casing.
                         4-ft by 4-ft concrete pad, 4 posts, 1 removable.
                         Capped and locked, brass cap in pad with well ID.
                         Not in radiation zone.
                         OTHER;
AVAILABLE LOGS      :    Geologist, Driller
TV SCAN COMMENTS    :    Not applicable
DATE EVALUATED      :    Not applicable
EVAL RECOMMENDATION :    Not applicable
LISTED USE          :    B-Pond monthly water level measurement, 19Oct88ÿ22Jul94
CURRENT USER        :    WHC ES&M w/l monitoring and RCRA sampling,
                         PNL sitewide w/l monitoring
PUMP TYPE           :    Hydrostar
MAINTENANCE         :
```

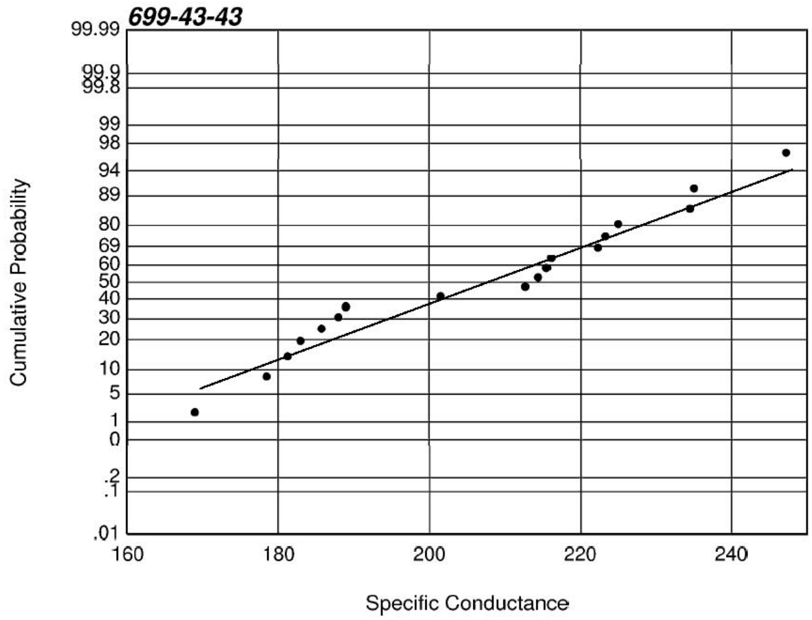
Appendix D

Normal Probability Plots

Appendix D

Normal Probability Plots

One of the assumptions for the combined Shewhart-CUSUM control chart approach is that the data are normally distributed. One simple and easy way to evaluate whether a sample can reasonably be regarded as having come from a normal distribution is through the use of a normal probability plot. The plot is constructed so that if data points fall on a straight line, then these data can be assumed as drawn from a normal distribution. Following the Ecology guidance letter[1], normal probability plots were generated and are presented here for each of the site-specific parameters in each B Pond system well using monitoring data obtained from January 1995 through June 2001. The normal probability plots suggest that the normal distribution is a reasonable assumption except for gross beta in 699-42-42B, which is better represented by a log-normally distribution (Note: the normal probability plot for gross beta from well 699-42-42B was plotted twice, the original scale is shown on the first figure, and log-transformed scale is shown on the second figure).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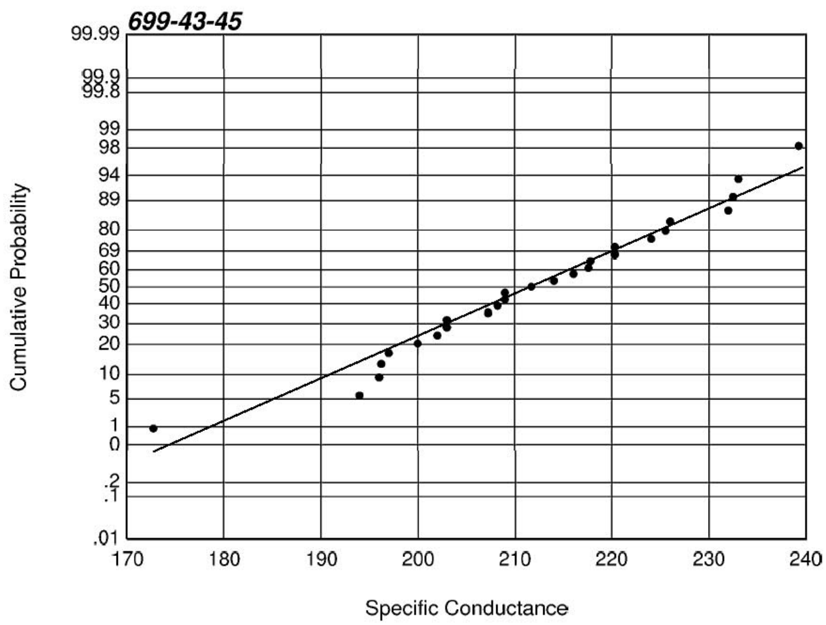
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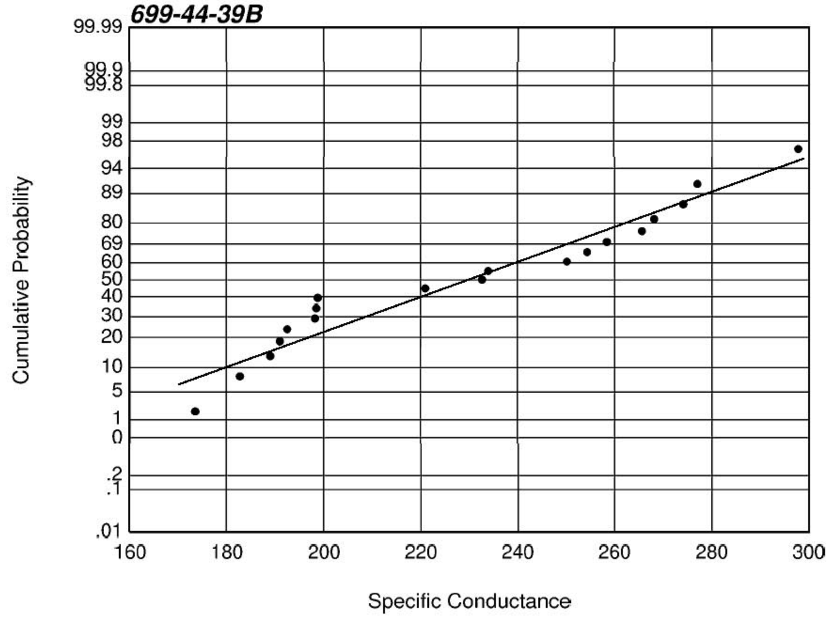
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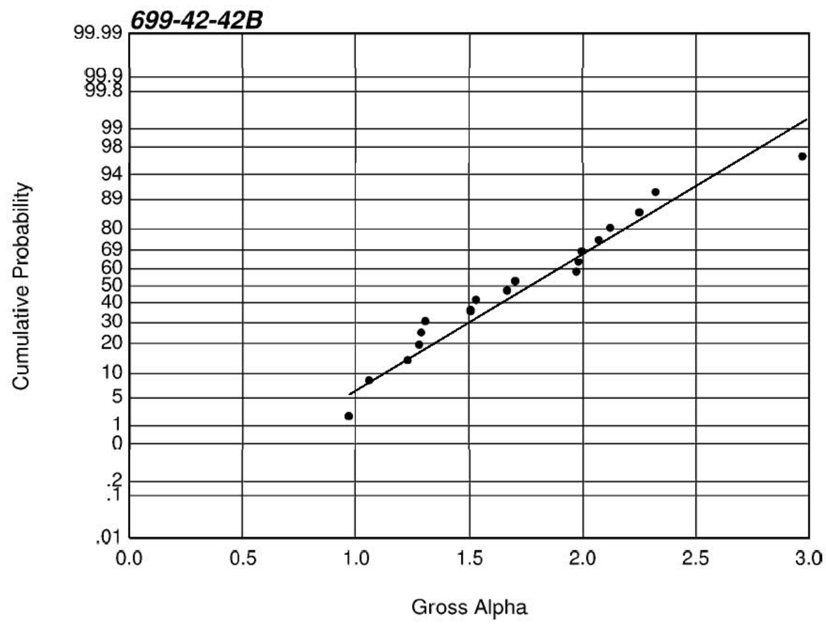
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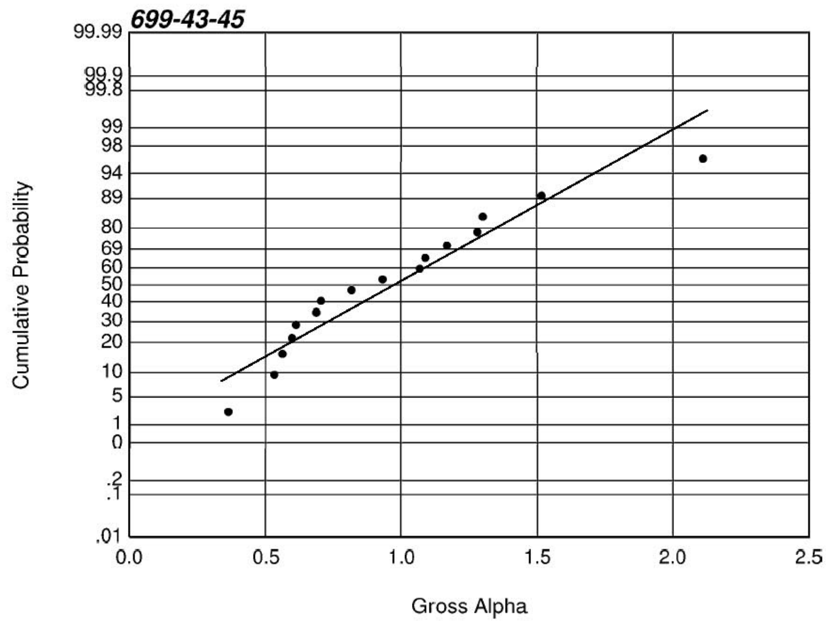
Gross Alpha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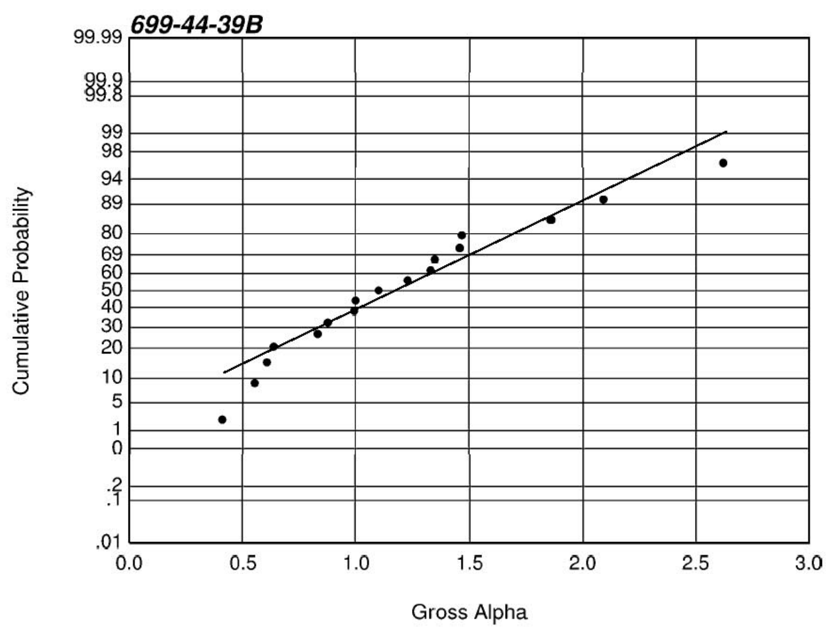
Gross Alpha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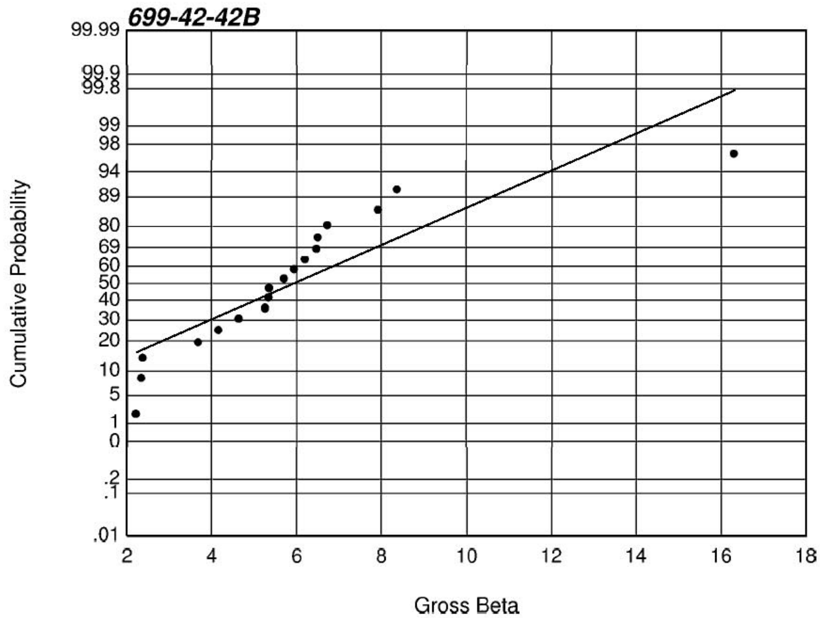
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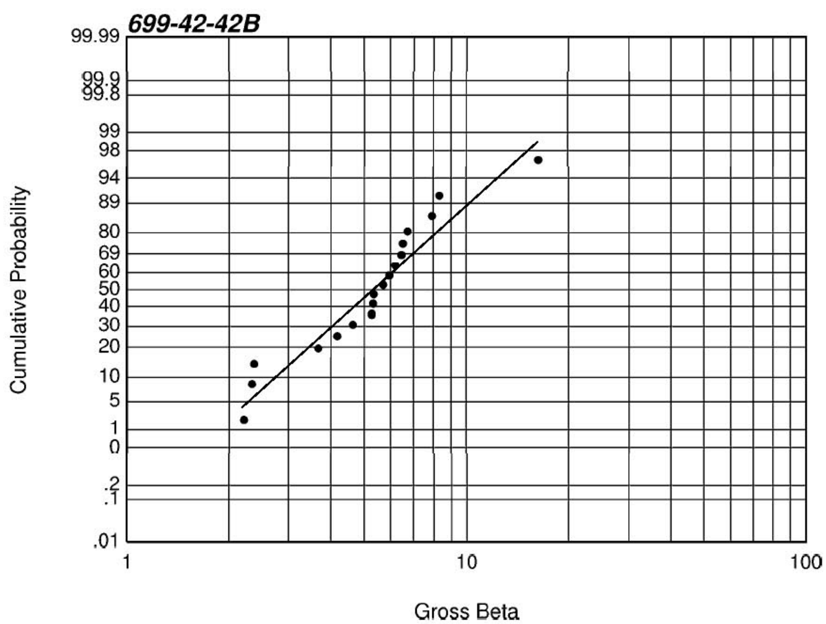
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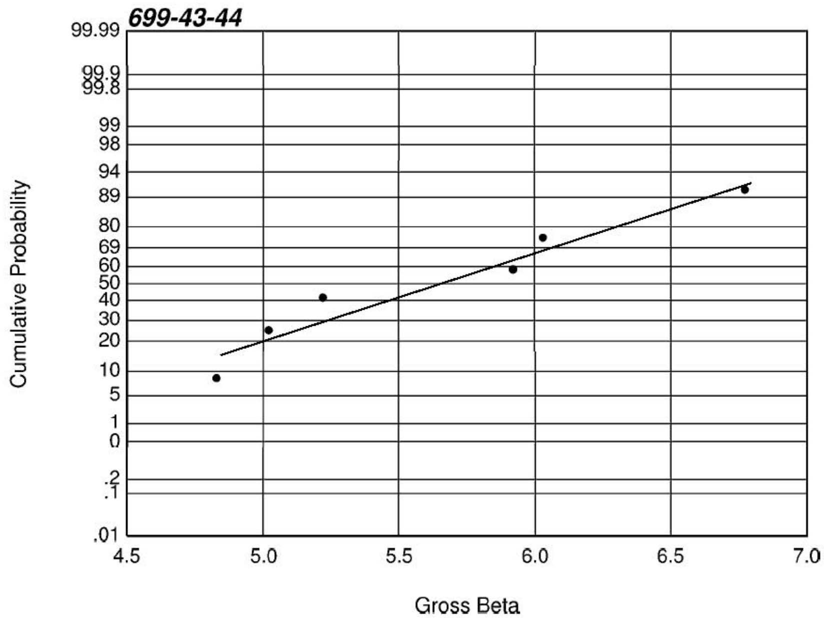
Gross Beta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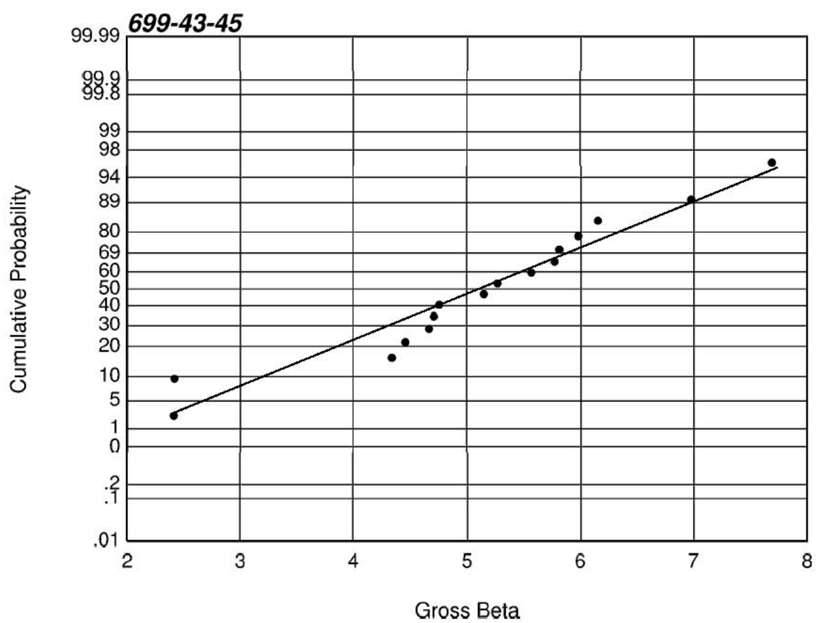
Gross Beta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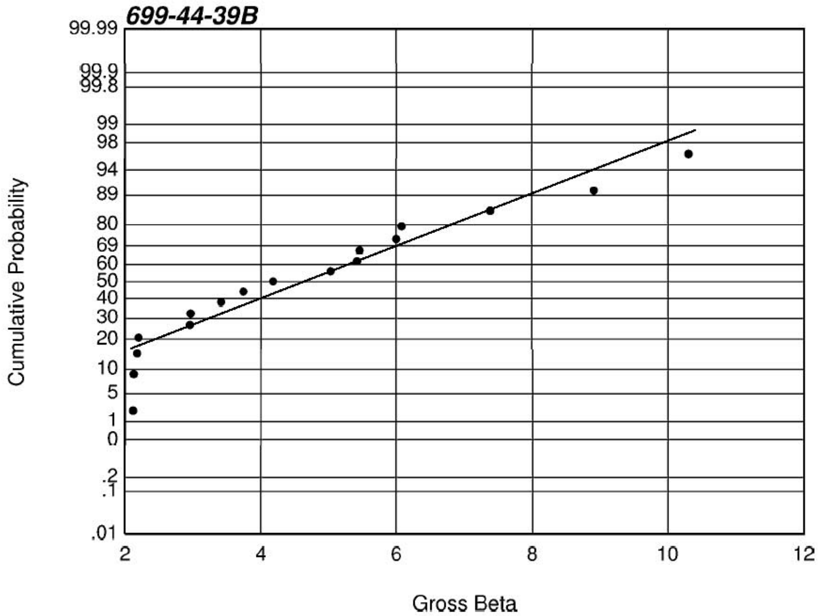
Gross Beta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Gross Beta

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