Appendix 17.D

Statistical Analysis of Phase I Interburden Sampling – 1998

No Name Project

Statistical Analysis of Phase I Interburden Sampling

Prepared For:

Ron C. Van Valkenburg, PE

William W. Skeet

BHP Minerals
New Mexico Coal
300 West Arrington, Suite 200
Farmington, NM 87401

Prepared By:

John W. Kern Ph.D.

Western EcoSystems Technology Inc.
2003 Central Ave
Cheyenne, WY 82001

3 August, 1998

TABLE OF CONTENTS

STATISTICAL ANALYSIS OF PHASE I INTERBURDEN DATA.....3

I. INTRODUCTION..... 3

II. LITHOLOGY AND NAMING CONVENTIONS..... 3

Geologic Cross Section..... 4

III. STATISTICAL METHODS..... 6

Proportion Suitable and Analyte Distributions..... 6

Volume of Suitable Material..... 7

Spatial Distribution of Suitable Interburden in I7A..... 8

Regression Analysis for Trend in Parameters..... 9

Statistical Quality Assurance..... 9

IV. RESULTS..... 9

Analyte Distribution..... 9

Confidence Intervals for Percent Suitable..... 9

Estimated Volume of Suitable Material in Interburden I7A..... 10

Spatial Distribution of Suitable Material within Interburden I7A..... 11

Isopach of Interburden I7A..... 12

Regression Analysis..... 12

Statistical Quality Assurance..... 12

V. CONCLUSIONS..... 12

STATISTICAL ANALYSIS OF PHASE I INTERBURDEN DATA

I. INTRODUCTION

The first phase of drilling to sample overburden at the No Name mine site consisted of 10 drill holes. Each drill hole resulted in continuous core samples through overburden, interburden and coal seams. The continuous cores were sampled at no greater than 5-foot increments for chemical assay and samples were taken at each change in lithology. The objectives of the phase I statistical analysis are to

1. Assess the adequacy of the phase I drilling program to conclude that either A) overburden is adequately sampled, or B) that further drilling is needed in order to make an adequate decision, and

2. Estimate the percent suitable material for reclamation and establishment of an adequate root zone to support vegetation,

3. Determine if particular stratigraphic layers contain high proportions of unsuitable materials,

4. Investigate spatial patterns in the proportion of suitable material and average value of analytes of interest,

5. Estimate the total volume of suitable material in the interburden layers most likely to be used for reclamation.

II. LITHOLOGY AND NAMING CONVENTIONS

The No Name mine area is composed of 8 coal seams and 8 corresponding overburden horizons with the Picture Cliffs sandstone comprising the deepest unit described in these investigations. Throughout this report, each interburden layer is referred to using the name of the coal seam directly below the layer.

Coal seams are numbered from deepest to shallowest. For example the deepest coal seam is seam 1 and the interburden above seam 1 and below seam 2 would be referred to as I1. In situations where there may be splits resulting in coal seams say 1A and 1B, then the interburden between these splits is referred to as I1A and I1B. Further if interburden layer I1A were composed of several horizons, say one horizon of primarily sandstone and the other of primarily shale, then the bottom horizon within this interburden would be labeled I1A1 and the next horizon above would be I1A2.

In general, each horizon within interburden is classified based on lithology, although some horizons may be composed of 2 or more lithologies, sandstone (SS), siltstone (SLTS) or shale (SH). Table 1 gives a list of each of the horizons and the composition of each in terms of percent of samples labeled SS, SLTS or SH. Thin (generally less than 12 inches) carbonaceous shale (CS) exists adjacent to the top or bottom of some coal seams. In most cases, the CS intervals were sent to the coal lab for BTU analysis and

have to date not been analyzed by the soil lab; therefore occurrences of CS are not included with this analysis and because of the small quantities of CS, the effects will not be significant. There were 9 interburden samples labeled as carbonaceous shale that have been eliminated from the analysis.

Geologic Cross Section

The locations of two cross sections through the No Name Mine area are shown in plan view in Figure 1, and cross sections one and two are presented in Figures 2 and 3. These cross sections are lumped into interburden layers (white) and coal layers (shaded). In addition to the cross sections, the mining area limit and combined polygons of influence are plotted for the area of influence of drill holes 498-01, 498-03, 498-04, 498-05, 498-06, 498-07. These polygons were selected for investigation because mixed material was 100 percent suitable within each of these drill holes.

Table 1. Interburden horizon labels and lithologic composition.

Horizon	Percent Sandstone	Percent Shale	Percent Siltstone	Number of Observations
I1A	25	42	33	12
I2A	18	55	27	11
I2B	100	0	0	1
I2C1	0	100	0	10
I2C2	80	0	20	15
I2C3	0	91	9	23
I3A	0	100	0	1
I3A 1	100	0	0	2
I3A 2	0	0	100	2
I3B	100	0	0	1
I3C	0	72	28	16
I4A	0	100	0	2
I4C1	5	86	9	22
I4C2	70	15	15	26
I4C3	0	100	0	25
I6A	0	100	0	3
I6B	0	100	0	15
I7A 1	0	100	0	10
I7A 2	88	0	11	18
I7A 3	0	100	0	9
I7A 4	100	0	0	1
I7A 5	0	100	0	1
I8A	0	100	0	2
I8B1	0	100	0	1
I8B2	85	15	0	7
I8C1	0	80	20	5
I8C2	61	13	26	23
I8C3	0	100	0	4
I9A	0	100	0	4
I9B1	0	100	0	2
I9B2	75	25	0	4
PCSS	Picture Cliffs Sandstone			15
T7A 2	Topsoil			4
T7A 3	Topsoil			4
T8A	Topsoil			4
T8B 2	Topsoil			1
T8C 2	Topsoil			8
T9B 2	Topsoil			4

III. STATISTICAL METHODS

Proportion Suitable and Analyte Distributions

Interburden characterization data were obtained from BHP's soil lab (Inter-mountain Laboratories, Inc.) in electronic spreadsheets. The data were exported to ASCII comma delimited text files for import into SAS statistical processing software. Analyses of interest include the characterization of percentage of suitable interburden material based on 9 analytes: sodium absorption ratio (SAR), pH, electrical conductivity (EC), acid-base potential (ABPT), texture (percent clay CLA) saturation percentage (SAT), Boron (B), and total and soluble Selenium (TSE and SSE). Determination of suitability was made on a sample by sample basis using both Office of Surface Mining guidelines and site specific guidelines currently in use at Navajo Mine. Due to the proximity of the No Name mine site to the Navajo Mine, a similar site-specific standard is appropriate. Office of Surface Mining southwestern United States, and Navajo Mine suitability criteria can be found in Table 2.

Table 2. Office of Surface Mining Reclamation and Enforcement, Southwestern United States and Navajo Mine suitability criteria.

	SUITABILITY LIMITS	
Characteristic	Navajo Mine Site Specific	OSM Southwestern U. S. Criteria
1. SAR	≤18 OR ≤40 only if EC≥4 mmhos/cm	sandy loam≤20 loam, clay loam≤16 40% clay≤14
2. pH	≥5 and ≤9	≥5.5 and ≤9.0
3. EC	≤16 mmhos/cm	≤12 mmhos/cm
4. Acid-Base Account	≥-5 t $CaCO_3$/1000 t	same
5. Texture	≥50% clay	≥45% clay
6. Saturation	≤85% OR ≤100% only if EC≥4 mmhos/cm	same
7. Boron	≤10 ppm	same
8. Total Selenium	≤0.8 ppm	same
9. Soluble Selenium	≤0.15 ppm	same

Box plots (Refer to Figures 6 to 14) were constructed to display the statistical distribution of analyte values as a function of lithology and interburden layer. The box in each plot represents the 25th and 75th percentiles. The horizontal line in each box represents the median. The whiskers represent the range of the data up to 1.5 times the box length (interquartile range) from the box center. Observations further from the box center are

plotted as ”+”symbols. Boxes that do not overlap can be thought of informally to represent differences in distribution, although this is not a rigorous statistical test.

Percent of suitable material was estimated within each interburden horizon. In general each horizon represented is composed primarily of one lithologic type (Table 1). The analysis methods followed Kern 1998, ***Draft Statistical Analysis Plan for Phase I Overburden Characterization Appendix A***. This is an analysis weighted by length of sample where each drill hole is treated as an independent experimental unit (i.e. a sample of at most 10 independent observations from each layer, with layers treated separately). The parameter estimates and precision were used to determine sample adequacy. For example, when the proportion suitable is very high or very low, low precision is acceptable and additional drilling would not be required. Conversely, if parameter estimates are marginal, then a higher level of precision is needed to make adequate decisions. The results of this analysis are presented in Figures 24 through 33 in plots of one-sided 90% confidence intervals for the percent of suitable material for each of 9 analytes.

Volume of Suitable Material

The total volume of material and total volume of suitable material in the I7A (interburden and overburden) was estimated. Information available from the 10 continuous core drill holes to estimate the percent suitable, and additional information on the total volume from 64 coal exploration drill holes was also used in the volume calculations. The analysis was applied to the mining area limit, within I7A, and to the combined polygons of influence for drill holes 498-01, 498-03, 498-04, 498-05, 498-06 and 498-07. These were the areas with the most suitable material.

In the mining process, mixing of the interburden material can be expected prior to reclamation as a result of loading, stockpiling and/or truck-dumping activities. Mixing will tend to improve the suitability of the material in that unsuitable intervals will tend to be diluted. An alternative approach is to utilize only the in-place (un-mixed) suitable materials for reclamation. Therefore, volumes of suitable material have been estimated under two conditions: 1) that the I7A interburden zone is mixed as a result of the mining process, and 2) that the in-place (un-mixed) suitable material is not mixed with intervals that are unsuitable. These conditions are evaluated because the mining and reclamation plans are likely to be different depending on whether interburden mixing is used.

Volume of in-place suitable material--Because additional coal exploration data are available, improved estimates can be constructed by estimating the total volume of an individual interburden layer independently from the continuous core data, and then multiplying by the proportion of suitable material. If V_{tot} represents the estimated total volume and $P_{suitable}$ represents the estimated proportion of suitable material, then the estimated volume of suitable material is

$$V_{suitable} = P_{suitable} V_{total}$$

and the estimated variance of the estimate is (Reed et al 1989)

$$\mathrm{var}(V_{suitabl}) = P^2{}_{suitable}\ \mathrm{var}(V_{total}) + V^2{}_{total}\ \mathrm{var}(P_{suitable}) - \mathrm{var}(P_{suitable})\ \mathrm{var}(V_{total}).$$

As described previously, the proportion of suitable material was estimated from the 10 continuous core drill holes. The total volume of material was estimated by kriging (Cressie 1991) the thickness of interburden layers using 64 additional drill holes from the exploratory drilling program. This allowed more accurate estimates of the volume of interburden layers than estimates based on the sparser continuous core data. Thickness was treated as the variable of interest and the mean thickness was estimated. When mean thickness is multiplied by total area of interest, it provides an estimate of the total volume. It should be noted that this is mathematically equivalent to developing kriged estimates of the thickness on a fine mesh grid using point kriging followed by adding the products of thickness by pixel area and summing. The advantage of this method is that variance estimates are also available for the estimated volume. In addition to estimating total volume, an isopach map showing interburden I7A over the mine site is provided in figure 5.

Volume of mixed suitable material--Although the volume of in-place suitable material can be estimated, it is of interest to consider the mixed volume of interburden and overburden which can be expected to be suitable. The continuous core data were averaged within interburden I7A and within drill hole and the resulting averages were compared to the suitability criteria to determine which areas could be expected to contain suitable interburden after mixing. The combined polygons of influence for these drill holes were used to delineate an area expected to be suitable after mixing. The total volume and a lower 90 percent confidence bound for mixed suitable material in interburden I7A was estimated using kriging.

Spatial Distribution of Suitable Interburden in I7A

The spatial distribution of suitable material was investigated in two ways;

1) The percent of suitable material on a sample by sample basis was plotted in plan view. Both OSM and Navajo criteria were investigated and results are displayed on Figure 4 as percent suitable by Navajo Mine Criteria / percent suitable by OSM criteria.

2) Under the assumption that material will be mixed in handling, data were pooled within interburden and drill hole, and the average analyte values were calculated using a weighted average with weights proportional to length of core. The weighted averages were compared to both OSM and Navajo criteria, and the results were posted in plan view showing which drill holes resulted in suitable average analyte values.

Regression Analysis for Trend in Parameters

If substantial gradients exist across the proposed mine site, one might encounter a situation where the mean parameters are suitable, while in fact there may be spatial strata which are composed of extremely poor material or extremely good material. In order to assess this question, a standard multiple regression analysis was conducted (Neter et al. 1996). The linear statistical model used was of the form

$$Analyte = \mu_0 + \mu_{litho\log y} + \beta_1 depth + \beta_2 Easting + \beta_3 Northing + Interactions + error$$

To take into account the unequal weighting inherent in the continuous core samples the regression coefficients and variance estimates were obtained using a weighted regression with weights proportional to the length of core sampled.

Statistical Quality Assurance

A set of 33 measurements was chosen for duplicate analysis following IML quality assurance procedures (QAP). To assess the relative magnitude of analytical error in the database, 95% confidence intervals were calculated for the relative difference between original measurements and duplicate measurements. Relative error was defined to be ([original value - duplicate value] / original value)**.** Reported values for boron, total and soluble selenium were occasionally zero resulting in relative errors that were not defined. For this reason the QA analysis for these analytes was reported in absolute units (ppm). Table (4) summarizes the results of this analysis.

IV. RESULTS

Analyte Distribution

Box plots of the distribution of each analyte are presented in figures 6 through 14 for all interburden layers pooled. Each analyte is broken out into separate box plots for each lithology, sandstone, shale and siltstone. It was found that interburden layer I7A was the most likely to provide adequate suitable material so box plots of analyte distributions are also presented by lithology within horizon I7A in figures 15 through 23.

Confidence Intervals for Percent Suitable

One-sided 90% confidence intervals for percent suitable material (Navajo Mine thresholds) are presented in graphical form in figures 24 through 34. Although the upper confidence limit on percent suitable is not of interest, it should be noted that the two-sided confidence interval should be interpreted as an 80% confidence interval. In general, it can be said that we are 90% confident that the true proportion of suitable material is greater than the lower confidence limit shown in the figures. These figures show that interburden I7A is the most promising target for suitable materials.

Estimated Volume of Suitable Material in Interburden I7A

All volumetric calculations are based on suitability for all analytes simultaneously. If the material is unsuitable for any analyte then it is considered unsuitable.

Volume of in-place suitable material-- Total volume of in-place suitable material in interburden I7A, and the overburden was estimated for the full mining area limit and in combined polygons of influence for drill holes 01, 03, 04, 05, 06, and 07. The results are summarized in table (3). Application of the kriging model requires estimation of a spatial correlation function. The estimated model was an isotropic spherical model with nugget effect 0.11 and range of influence 3,463 feet.

The estimated total volume of interburden I7A over the mining area limit is 91.7 Mcy. Of that, the estimated in-place volume of suitable material is 37.6 Mcy with a standard error of 12.4 Mcy. The estimated probability that there are at least 21.8 Mcy of in-place suitable material in the planned mine area in interburden I7A is 90%.

When interburden I7A is restricted to just the polygons of influence associated with drill holes 01, 03, 04, 05, 06, and 07, (those with suitable mixed material), the total volume of material is estimated to be 47.0 Mcy. The estimated volume of in-place suitable material is 36.2 Mcy with standard error 13.0 Mcy. The probability that there are at least 19.4 Mcy of in-place suitable material in this portion of the planned mine area in interburden I7A is 90%.

Table 3. Estimated volume of suitable material based on estimates of percent suitable from continuous core drilling and average thickness based on coal exploration drilling.

				Mixed Volume			In-place Volume		
Region	Surface Area $1x10^6$ ft^2	Percent Suitable	SE	Total Volume $1x10^6$ yd^3	SE Feet	Lower 90% Limit $1x10^6$ yd^3	Volume Suitable $1x10^6$ yd^3	SE $1x10^6$ yd^3	Lower 90% Limit $1x10^6$ yd^3
Mining Area Limit Overburden	153.7 ($17x10^6$ yd^2)	48%	15%	127.7	8.0	116.8	60.9	18.9	36.8
Polygons 1 3 4 5 6 7 Overburden	74.42	67%	28%	60.0 [a]	5.0	43.6 [a]	40.0	17.0	18.0
Mining Area Limit I7A Interburden	153.7 ($17x10^6$ yd^2)	41%	13%	91.7	3.6	87.1	37.6	12.4	21.8
Polygons 1 3 4 5 6 7 I7A Interburden	74.42	77%	28%	47.0 [a]	2.2	44.2 [a]	36.2	13.0	19.4
Overburden Seam 8	38.78	81%	28%	32.5 [a]	6.7	23.9 [a]	26.1	7.3	16.8

[a] Suitable material when mixing occurs.

Volume of suitable mixed interburden material in I7A—The estimated total volume of suitable mixed interburden material in interburden I7A within the combined polygons of influence for drill holes 01, 03, 04, 05, 06, and 07, is 47.0 Mcy. The probability that there are at least 44.2 Mcy of suitable mixed material in this portion of the planned mine area in interburden I7A is 90%.

Sample adequacy – There are at least two ways to demonstrate that adequate in-place suitable material exists in the permit area with 90% confidence. First, there is a 90% probability that the volume of in-place suitable material in the overburden, (material above uppermost coal seam) is at least 36.8 Mcy. Second, the total combined volume in the overburden associated with seam 8 and the material in the I7A interburden is estimated to be greater than 16.8+19.4 = 36.2 Mcy with 90% confidence. Either of these estimates indicates that the total volume is well above the 22.7 Mcy needed for successful reclamation.

Spatial Distribution of Suitable Material within Interburden I7A

Weighted averages of analyte values were computed for each drill hole. These values were compared to OSM and Navajo Mine criteria to assess the spatial distribution of suitable material after mixing, in anticipation of the mining and handling process. Drill holes were marked with a solid circle if all analytes passed the OSM southwestern United States Criteria, and drill holes were marked with a hatched circle if one or more OSM criteria were not met, while the Navajo Mine criteria were met for all analytes. The results of these investigations can be seen in figure (2). When mixing is assumed, drill

holes 498-01, -03, -04, -05, and -06 contained suitable material by OSM criteria. In addition, mixed material in drill hole 498-07 was suitable by Navajo Mine Site specific criteria.

Isopach of Interburden I7A

Analysis of the interburden thickness data resulted in spatial correlations which ranged up to 3,463 feet but which included a nugget effect of 0.11. These parameters were used to krige the 74 isopach measurements to develop point estimates of the isopach on a regular grid with 200 foot spacing. The resulting isopach map can be seen in figure (5).

Regression Analysis

Regression analysis results are presented in Table 5, where R-squared statistics are listed along with variables that are statistically significant predictors of analyte values. In particular, acid base potential, percent clay, percent saturation and soluble selenium each vary with lithology. These relationships to lithology are most easily discerned by looking at the box plots. For example the distribution of acid base potential (figure 6) shows that ABP is significantly higher in sandstone and siltstone than in shale. Similarly, (and perhaps obviously) percent clay also varies across lithology (R^2 = 0.72), as one would expect with shale, siltstone and topsoil all having more clay than sandstone. In addition, there is an interaction between depth and lithology and easting and lithology. The indication of significant interactions is that percent clay may be increasing with easting for some lithologies and decreasing or not changing with easting for others. For further interpretation of these relationships one is referred to Appendix B, where full regression outputs are available. Selenium concentration is also correlated with lithology, easting and depth (R^2 = 0.61). Again for additional interpretation see Appendix B.

Statistical Quality Assurance

A summary of results of the statistical quality assurance can be found in Table 4. Average relative analytical measurement error was less than 2 percent for pH, EC, SAT, SAR, CLAY, Neut-pot, and Total Sulfur. Ninety five percent confidence intervals for the average error ranged from –4% to 6.57%. Because Boron, and total and soluble SE were often recorded as 0.00 when rounded to 2 decimals, absolute precision was calculated for these analytes. Duplicate measurements for Boron were on average within 0.015 ppm with a 95% interval of (-0.04, 0.1 ppm). Total selenium averaged $1x10^{-18}$ ppm with a 95% confidence interval of (-0.008, 0.012). Soluble selenium averaged 0.0064 (ppm) analytical error, with a 95% confidence interval of (–0.002, 0.020). IML quality standards are that duplicate analytical measurements are within 15% of original measurements.

V. CONCLUSIONS

The primary objective of these investigations is to identify interburden horizons that contain sufficient volume of material suitable for establishment of a root zone in reclamation, and to determine if the present level of drilling is adequate to characterize the volume of suitable material.

Based on the plots of percent suitable by analyte and interburden layer, I7A interburden is the most likely interburden layer to contain adequate suitable material. There may be smaller pockets of suitable material within other interburden layers such as I8 and I9 although I7A was the primary focus of these investigations. If I7A can be established as containing adequate volume, then any additional interburden layers later found to contain suitable material can simply be incorporated in the mine plan.

The 10 continuous core samples used to estimate the percentage of suitable material represent a random sample of the mining area limit. As such, statistical inferences apply to this region. To make a decision regarding drilling adequacy, some form of definition of adequacy is required. In these studies, adequacy is defined to mean sufficient number of samples to allow a decision *with 90% statistical confidence* that either yes, *there is sufficient volume of mixed suitable material, or no there is not sufficient volume of mixed suitable material* for reclamation. An inadequate number of drill holes would be characterized by a situation where neither of the above statements can be made, (i.e. 90% confidence intervals for volume of mixed suitable material overlap the minimum volume of material needed to reclaim). Based on a target of 4 feet of soil depth over all of the mining area limit (3530 acres) 22.7 Mcy of suitable material are needed.

In the mining process, mixing of the interburden material can be expected prior to reclamation as a result of loading, stockpiling and/or truck-dumping activities. Mixing will tend to improve the suitability of the material in that unsuitable intervals will tend to be diluted. An alternative approach is to utilize only the in-place (un-mixed) suitable materials for reclamation. Therefore, volumes of suitable material have been estimated under two conditions (see Table 3): 1) that the I7A interburden zone is mixed as a result of the mining process, and 2) that the in-place (un-mixed) suitable material is not mixed with intervals that are unsuitable. These conditions are evaluated because the mining and reclamation plans are likely to be different depending on whether interburden mixing is used.

Consider the total volume of mixed suitable material (i.e. material from the polygons of influence for drill holes 01, 03, 04, 05, 06, and 07). Based on the 64 drill holes from coal exploration drilling and the 10 continuous core holes (i.e. N=74 total), the estimated total volume of mixed suitable material is 47.0 Mcy. ***Based on this analysis, we can say with 90% confidence that the volume of mixed suitable material in the combined polygons of influence for holes 1,3,4,5,6,and 7 in I7A interburden (44.2 Mcy) is greater than the needed 22.7 Mcy.***

It has also been shown with 90% confidence that the volume of in-place (un-mixed) suitable material in the combined polygons of influence for holes 1, 3, 4, 5, 6 and 7 in the I7A interburden plus the I8 overburden combined is at least 36.2 Mcy. There is also a 90% probability that the volume of in-place suitable material in the overburden, (material above uppermost coal seam) is at least 36.8 Mcy

In summary, it has been demonstrated with 90% confidence that there is sufficient mixed suitable material from the I7A interburden zone to allow development of a 4-foot root zone as part of the reclamation strategy. It has also been demonstrated with 90% confidence that there is sufficient in-place (un-mixed) suitable material from the I7A interburden and I8 overburden zones to allow development of a 4-foot root zone. It can be concluded based on these studies that additional drilling to verify the presence of adequate volume of suitable material is not required in order to proceed with mine planning.

Table 4. Statistical quality assurance analysis of laboratory duplicate chemical analysis. Ninety five percent confidence intervals were developed for the relative difference between duplicates and original measurements. When upper confidence limits are positive and lower confidence limits are negative the relative error is not significantly different from zero.

	PH	EC	SAT	SAR	CLAY	Neut-pot	Total Sulphur	Boron[a] (ppm)	Total Se[a] (ppm)	Soluble Se[a] (ppm)
Mean	-0.07%	2.00%	-0.42%	0.04%	-0.32%	-1.73%	-1.73%	0.015	1.7e-18	0.0064
Variance	0.001%	0.65%	0.10%	1.01%	0.06%	0.36%	0.42%	0.023	0.0005	0.0005
Lower Confidence Limit	-0.21%	-0.91%	-1.56%	-3.58%	-1.23%	-3.90%	-4.05%	-0.039	-0.008	-0.0020
Upper Confidence Limit	0.15%	6.57%	1.36%	5.72%	1.11%	1.68%	1.92%	0.101	0.012	0.0195

[a] Boron and total and soluble selenium are reported in absolute units (ppm) because reported values were often 0.00 ppm when rounded to 2 significant digits.

Table 5. Summary of regression analysis results. The models were fit one analyte at a time and the table presents R-squared values for all models and lists variables (if any) which were statistically significant at the 10% level.

Analyte (Dependent Variable)	R^2	Significant parameters at p<0.10 Parameter	Statistical Significance
Acid Base Potential (ABP)	0.53	Lithology	0.044
Boron (BOR)	0.57	None	p>0.14
Percent Clay (CLA)	0.79	Lithology	0.001
		Easting	0.034
		Easting*Lithology	0.001
EC	0.43	None	p>0.15
PH	0.48	None	p>0.13
Sodium Absorption Ratio (SAR)	0.49	None	p>0.16
Percent Saturation (SAT)	0.51	Lithology	0.09
		Depth*Lithology	0.06
		Easting*Lithology	0.09
Soluble Selenium (SSE)	0.24	None	p>0.23
Total Selenium	0.63	Lithology	0.003
		Depth	0.001
		Easting	0.001
		Depth*Lithology	0.001
		Easting*Lithology	0.004

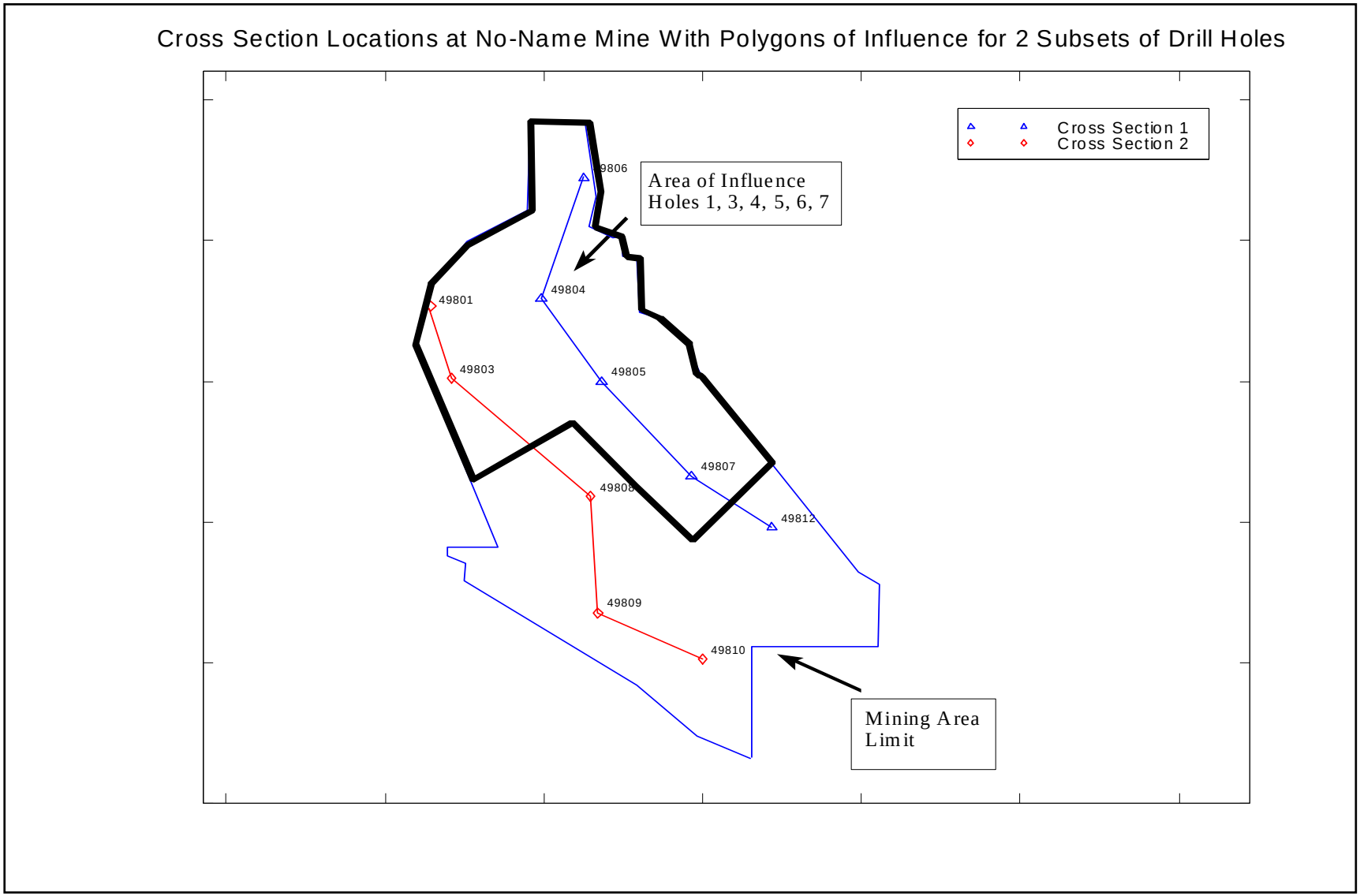

Figure 1. **Plan view of No Name mining area limit with locations of cross sections (1) and (2) and combined polygons of influence associated with continuous core samples 498-01, 498-03, 498-04, 498-05, 498-06, and 498-07. Total volume of suitable material was estimated on both polygons.**

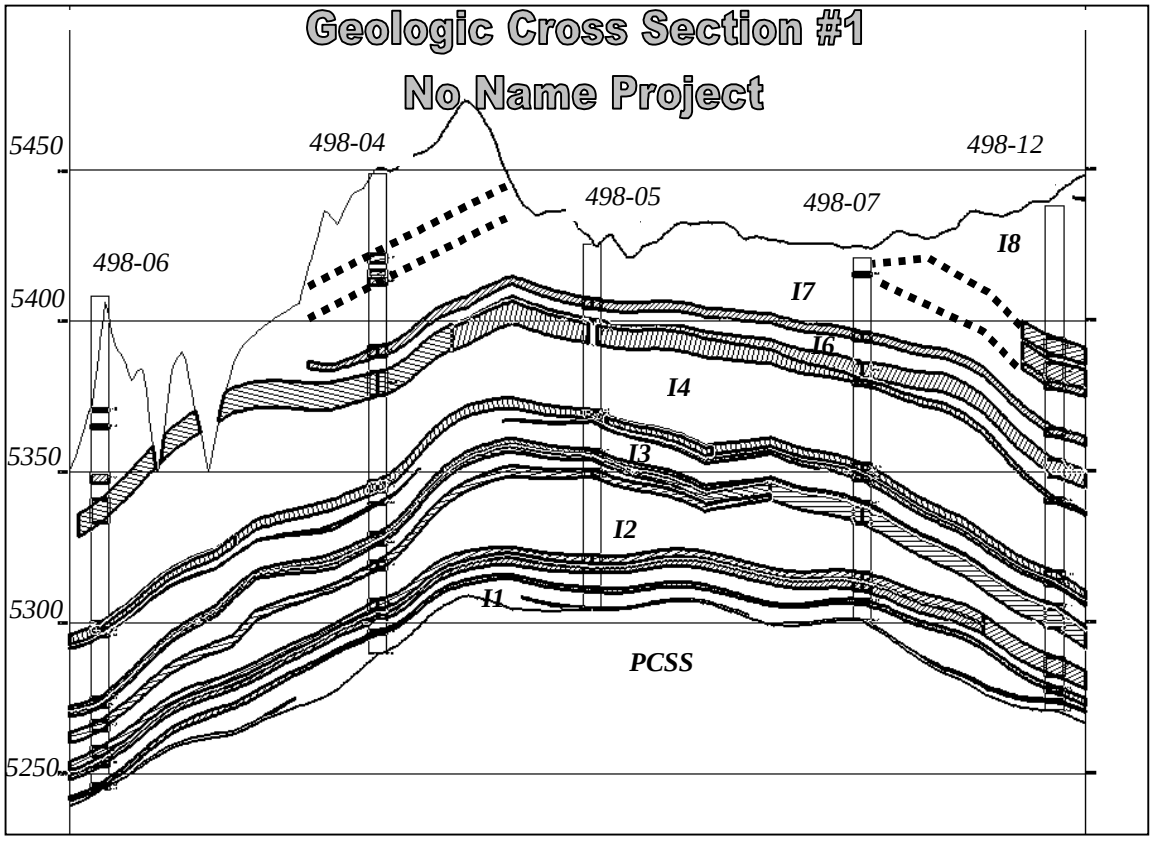

Figure 2. Geologic cross section number 1 at the No Name mine site. For a plan view, see figure (1).

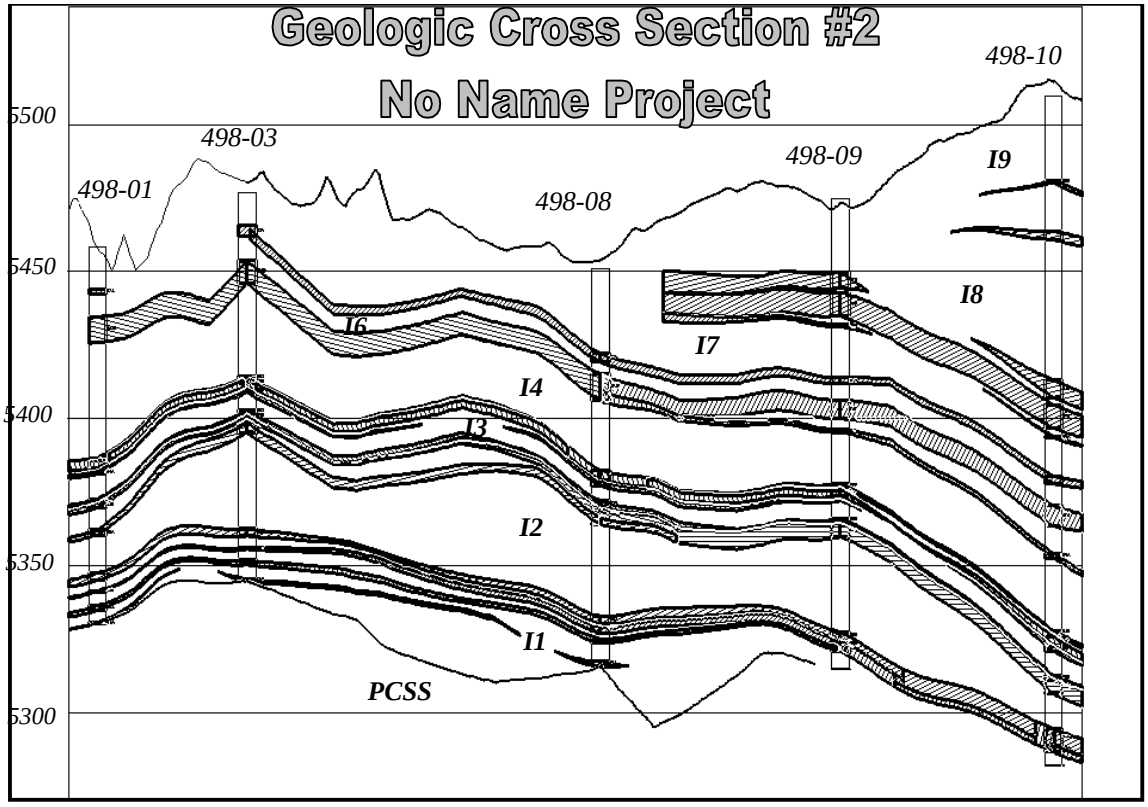

Figure 3. **Geologic cross section number 2 at the No Name mine site. For a plan view, see figure (1).**

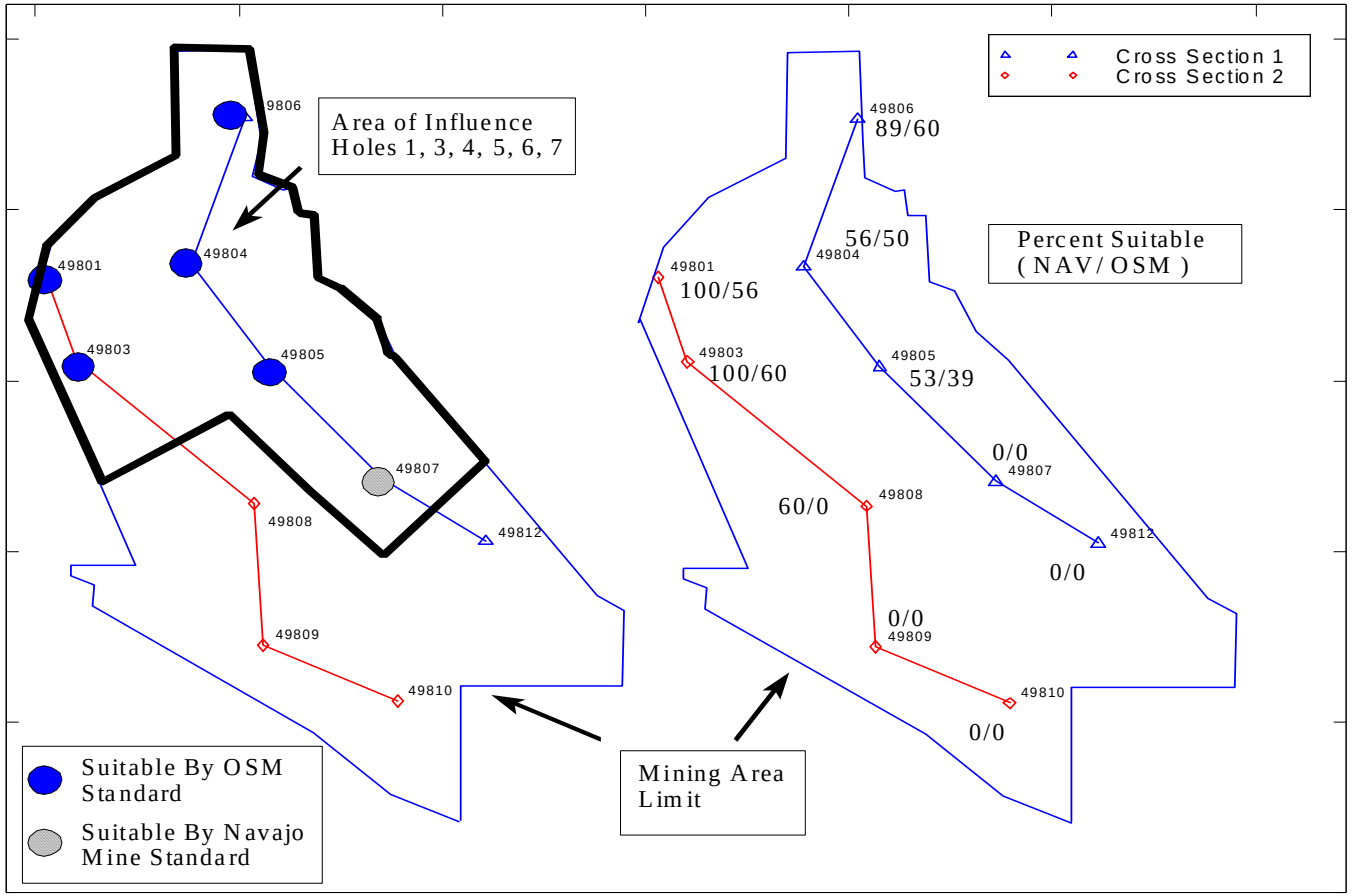

Figure 4. **Spatial distribution of Suitable material in the I7A interburden at the No Name mine site. In the left pane, filled circles indicate that the weighted average of each analyte met OSM and Navajo Mine criteria. Hatched circles indicate that the Navajo Mine criteria were met but the OSM criteria were not. In the right pane, the percentage of suitable material on a sample by sample basisi is posted at each drill hole. The percentages are listed by (Navajo Criteria/OSM Criteria). Drill hole 498-08 failed on SE=1.3ppm.**

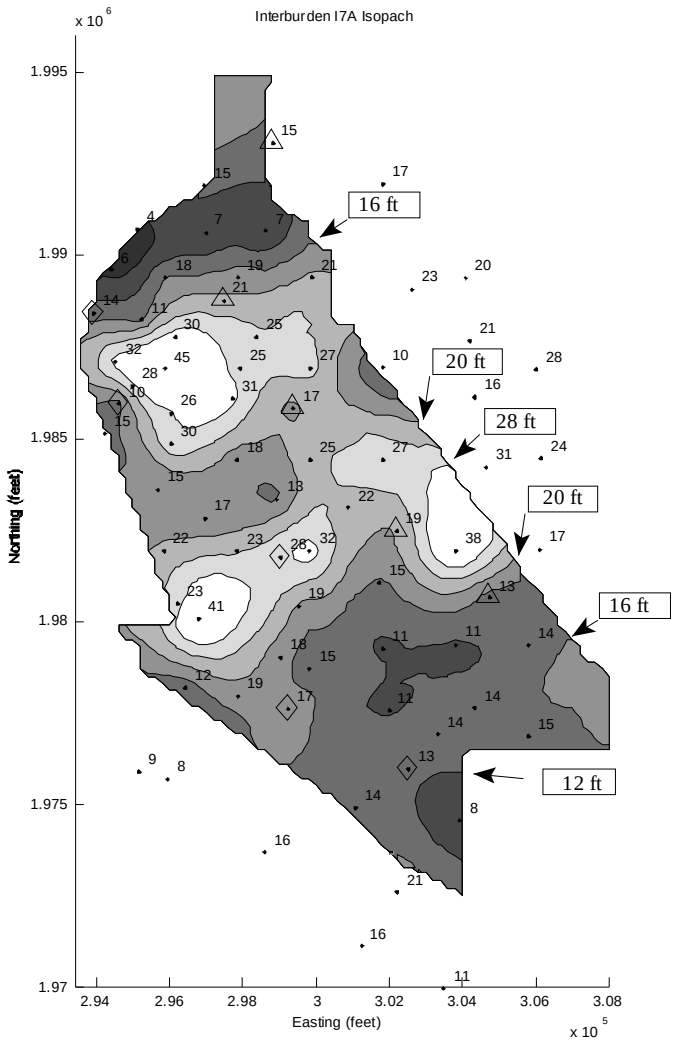

Figure 5. **Kriged isopach map of the I7A interburden at the No Name mine site. The contour interval is 4 feet and the actual data are posted. Triangles represent drill holes on cross section 1 and diamonds represent drill holes on cross section 2.**

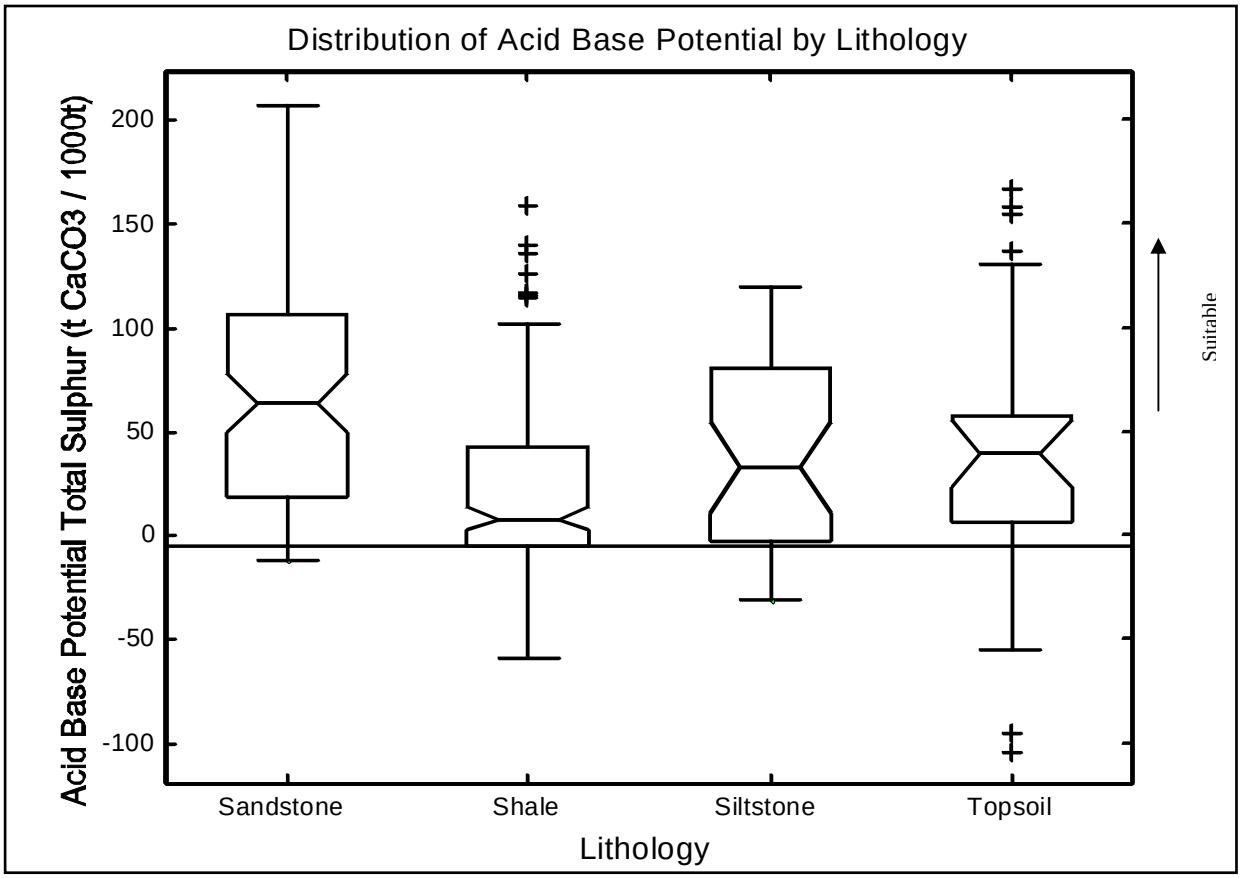

Figure 6. Box and whisker plots of Acid Base Potential stratified by lithology for all interburden layers. The box represents the 25th and 75 th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal line represents the Navajo Mine site specific standard for suitability.

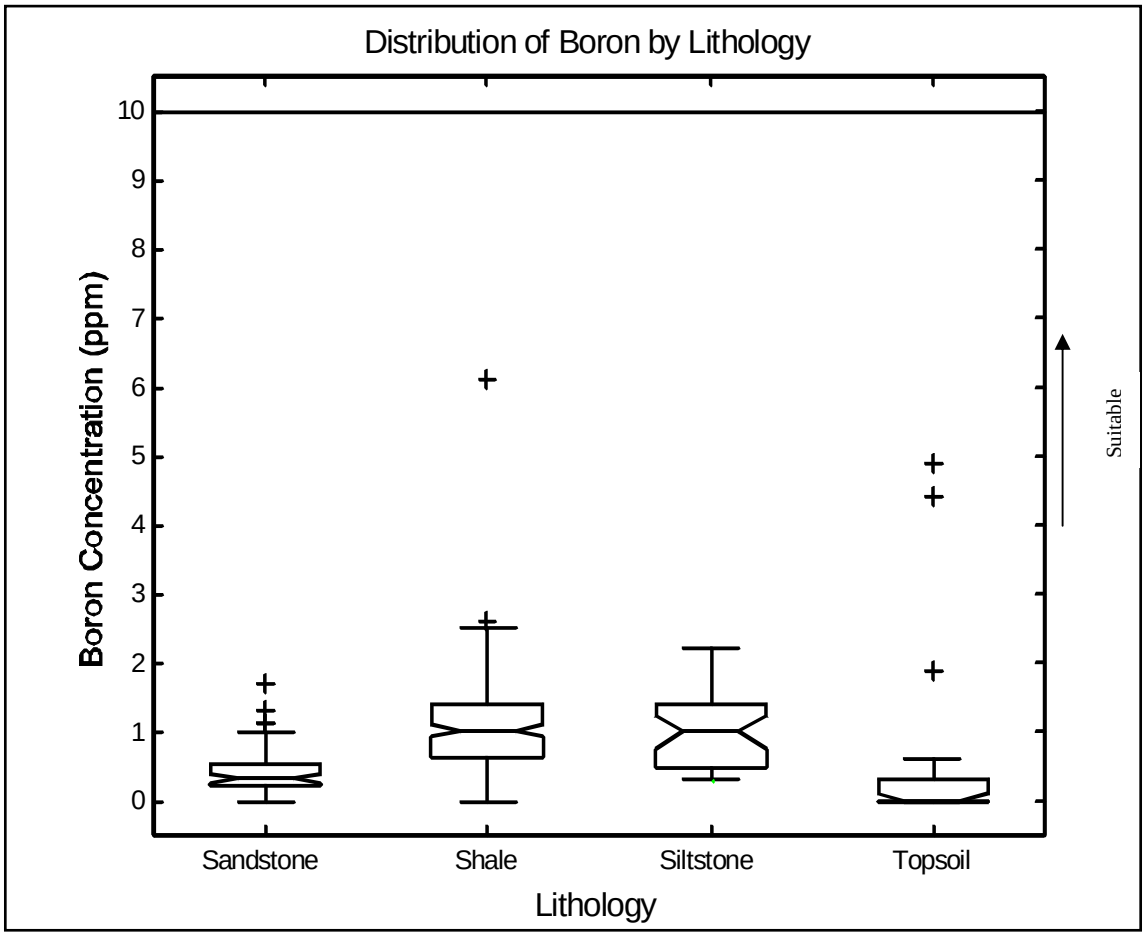

Figure 7. **Box and whisker plots of Boron concentration in parts per million stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal line represents the Navajo Mine site specific standard for suitability.**

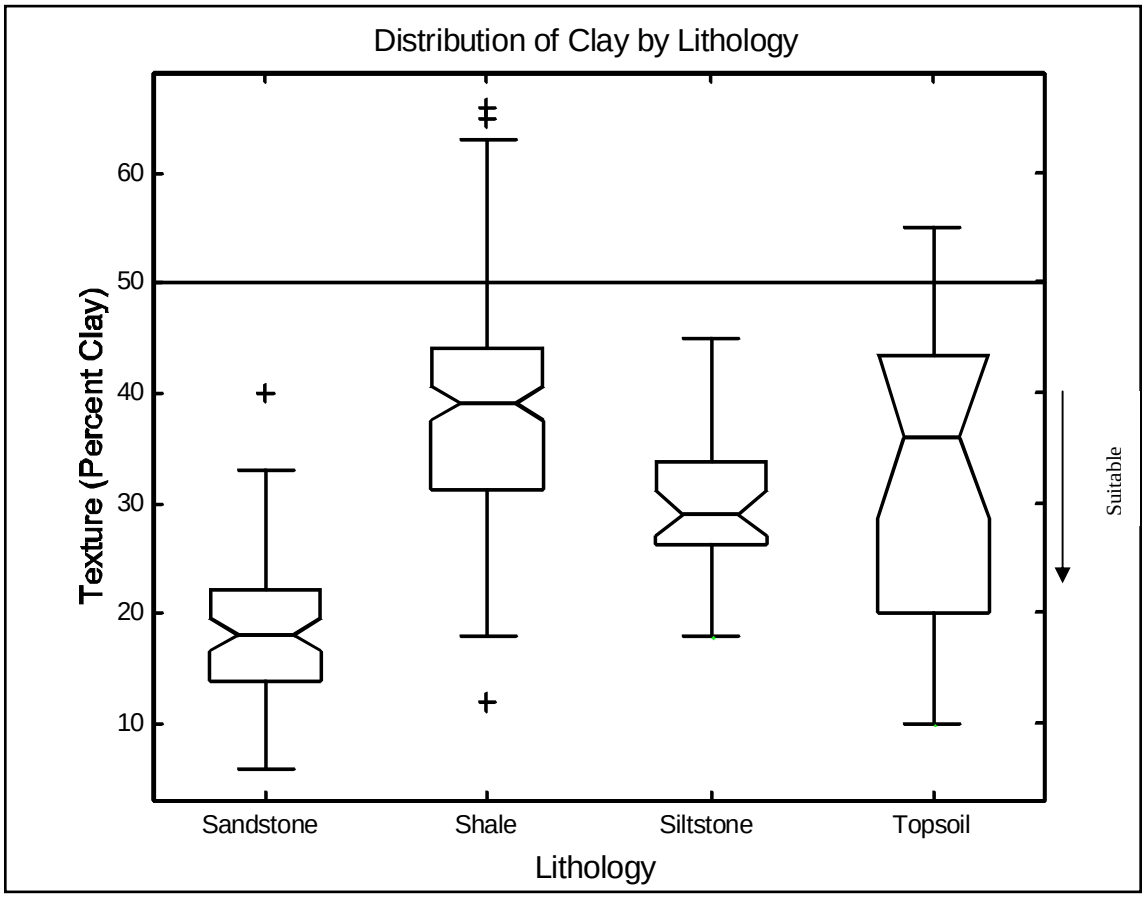

Figure 8. **Box and whisker plots of percent clay stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal line represents the Navajo Mine site specific standard for suitability.**

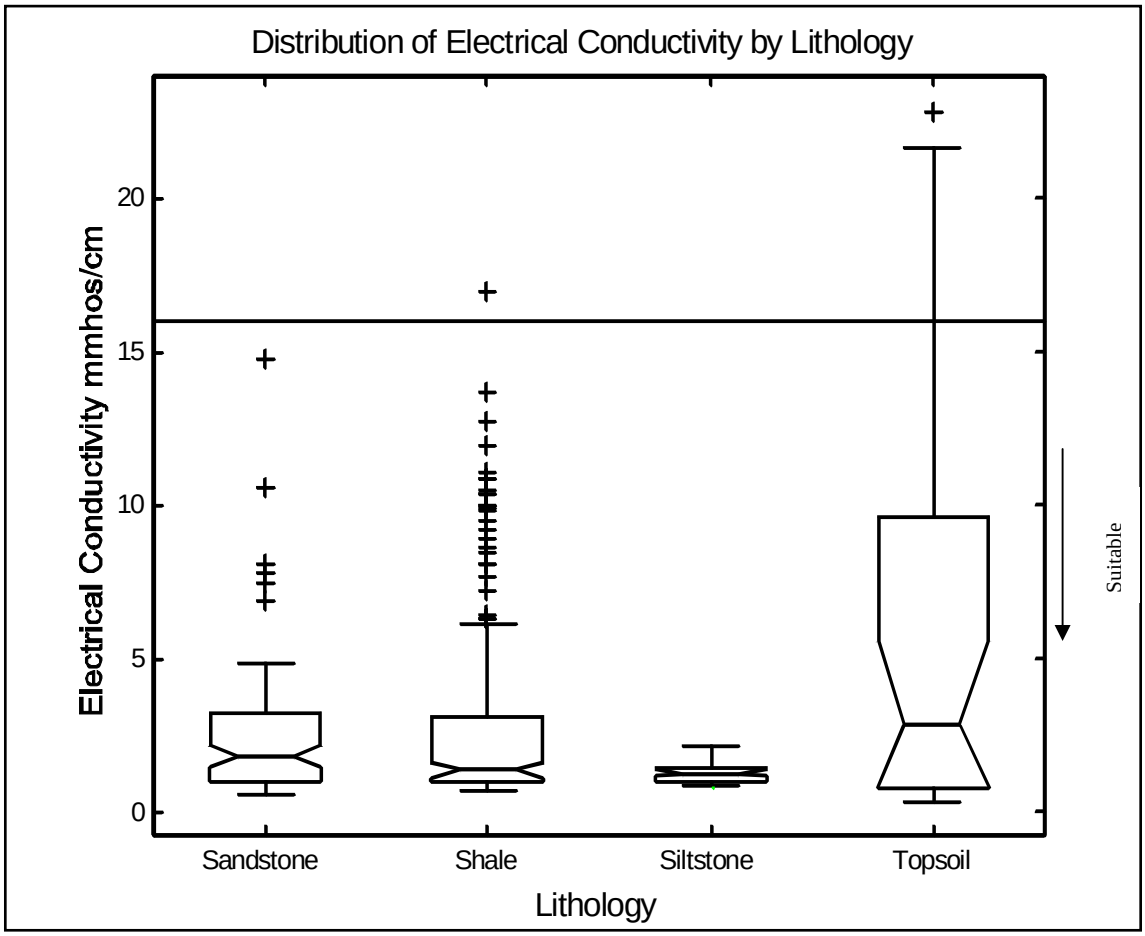

Figure 9. **Box and whisker plots of electrical conductivity stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal line represents the Navajo Mine site specific standard for suitability.**

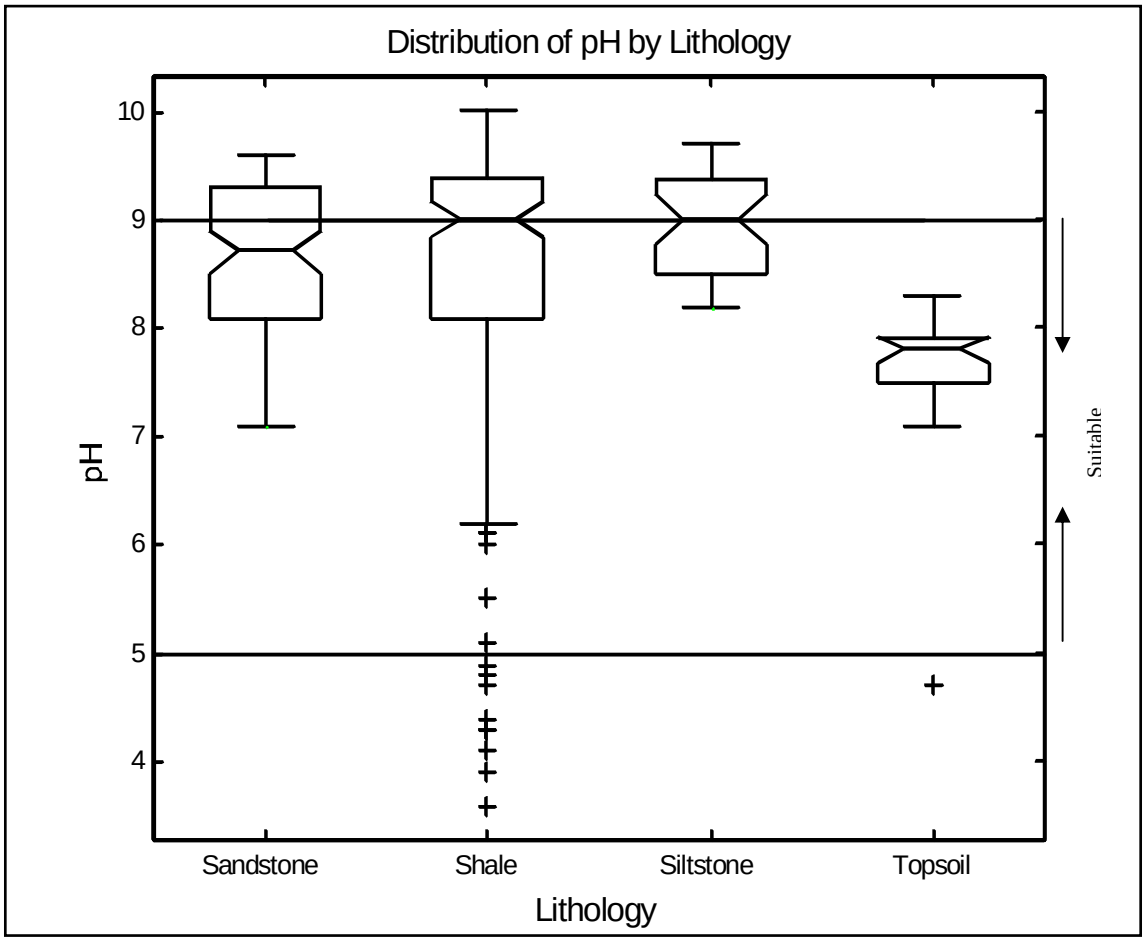

Figure 10. **Box and whisker plots of pH stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal line represents the Navajo Mine site specific standard for suitability.**

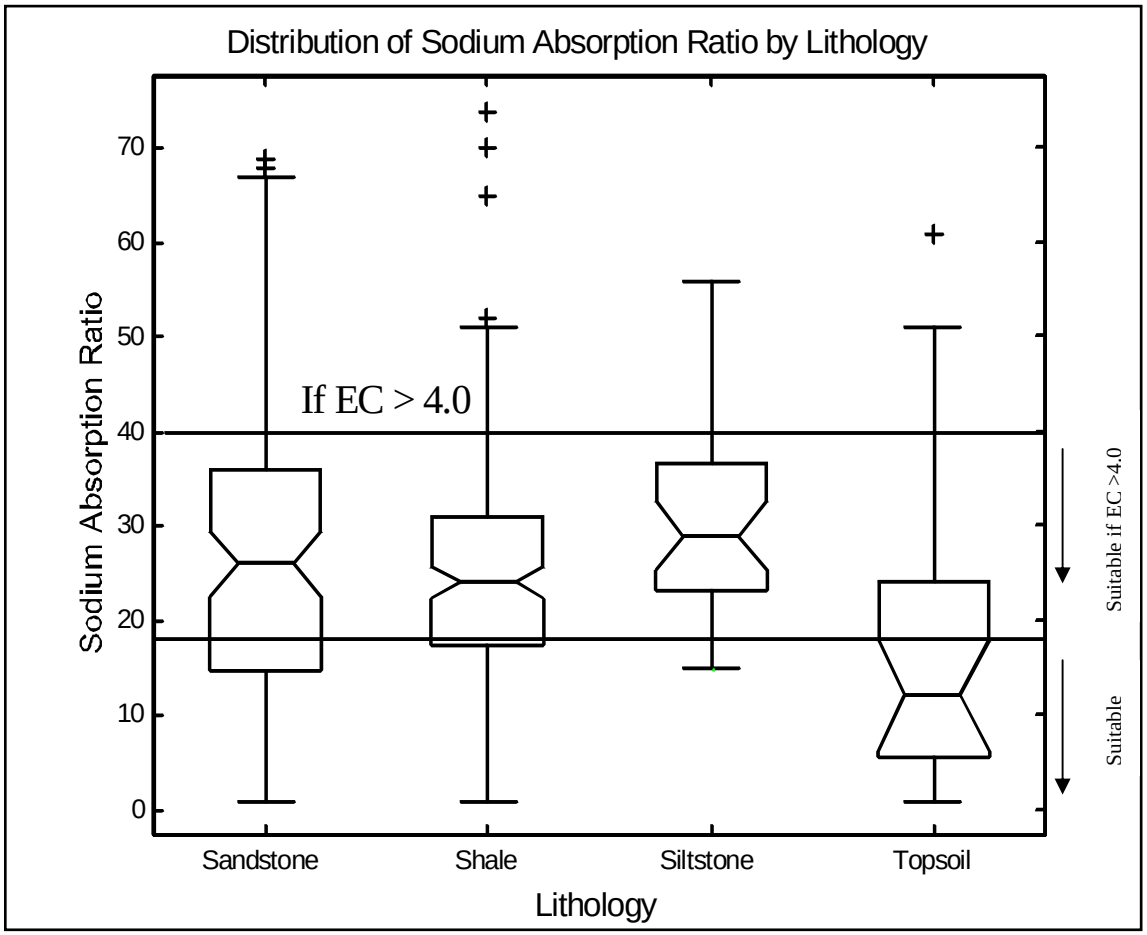

Figure 11. **Box and whisker plots of sodium absorption rate stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

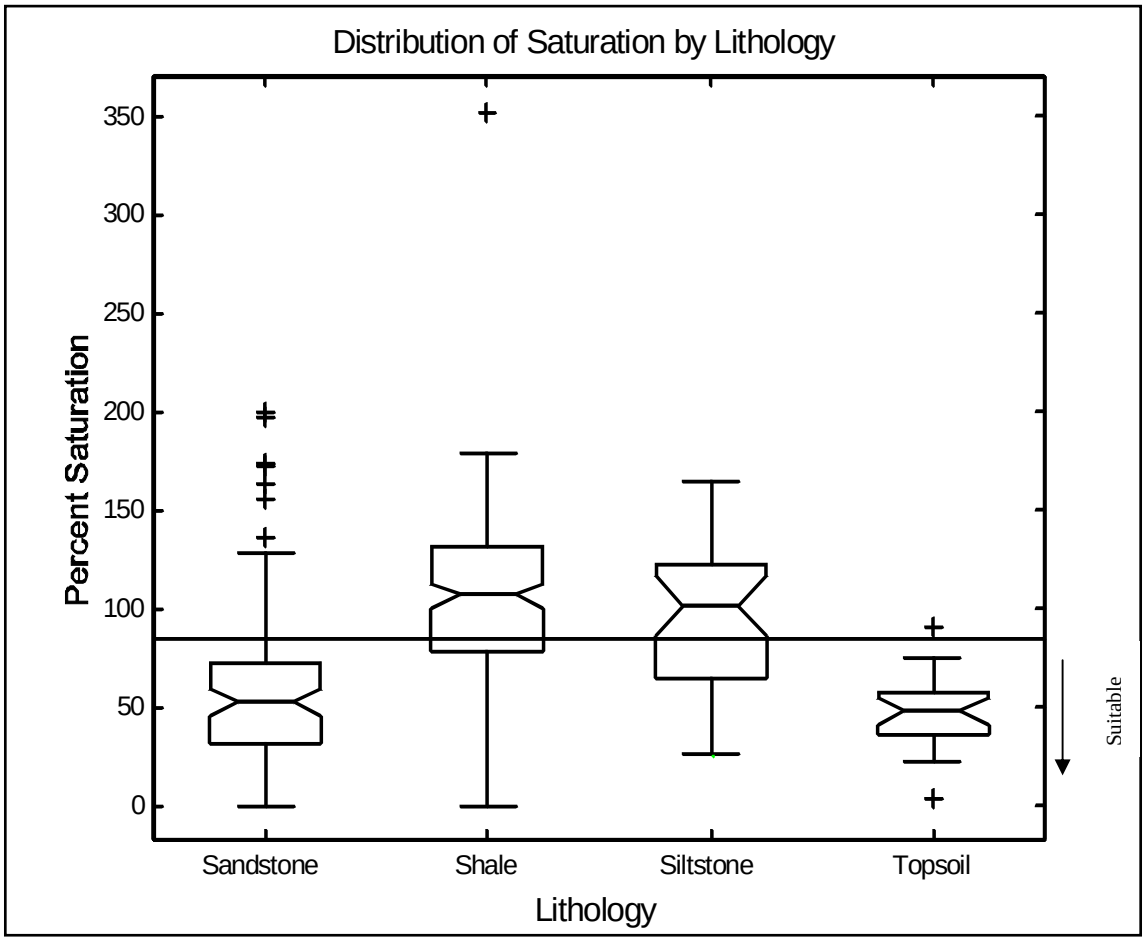

Figure 12. **Box and whisker plots of percent saturation stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

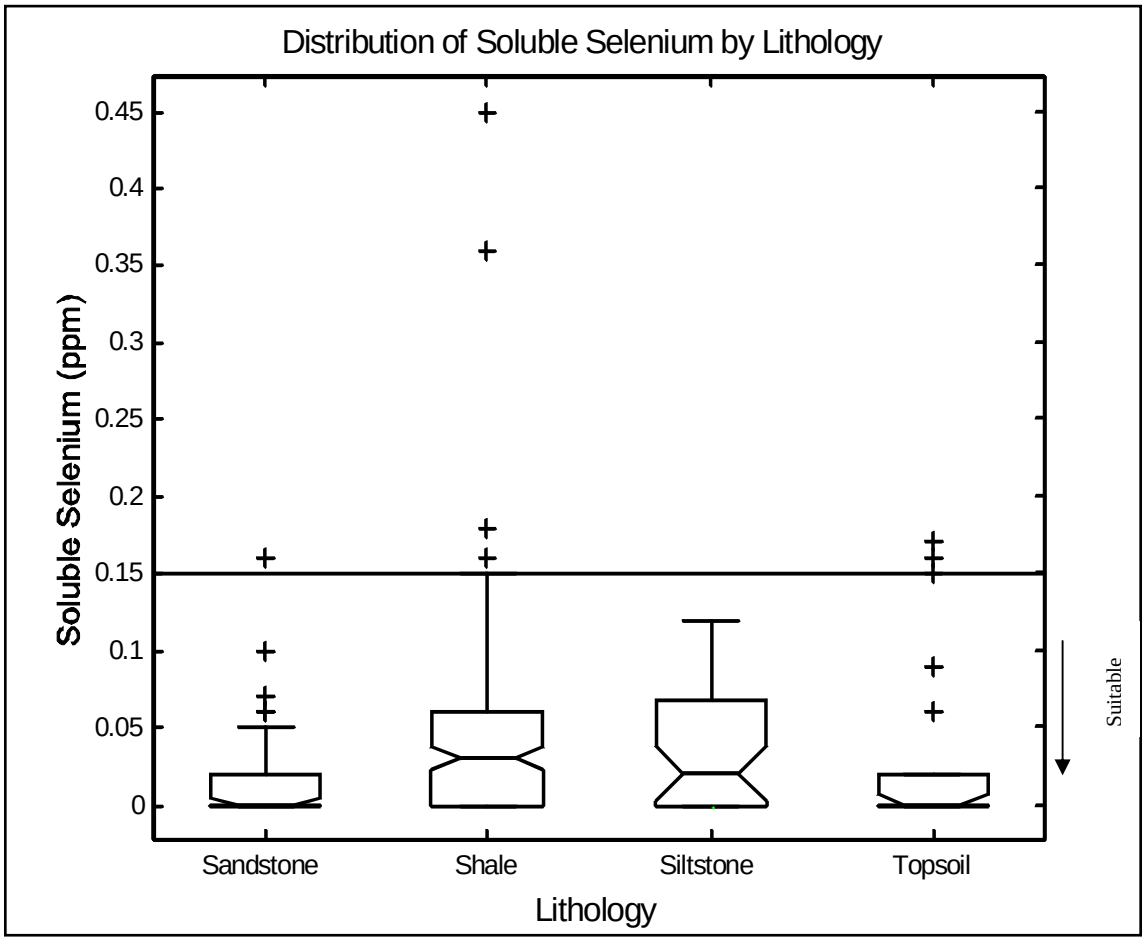

Figure 13. **Box and whisker plots of soluble selenium by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

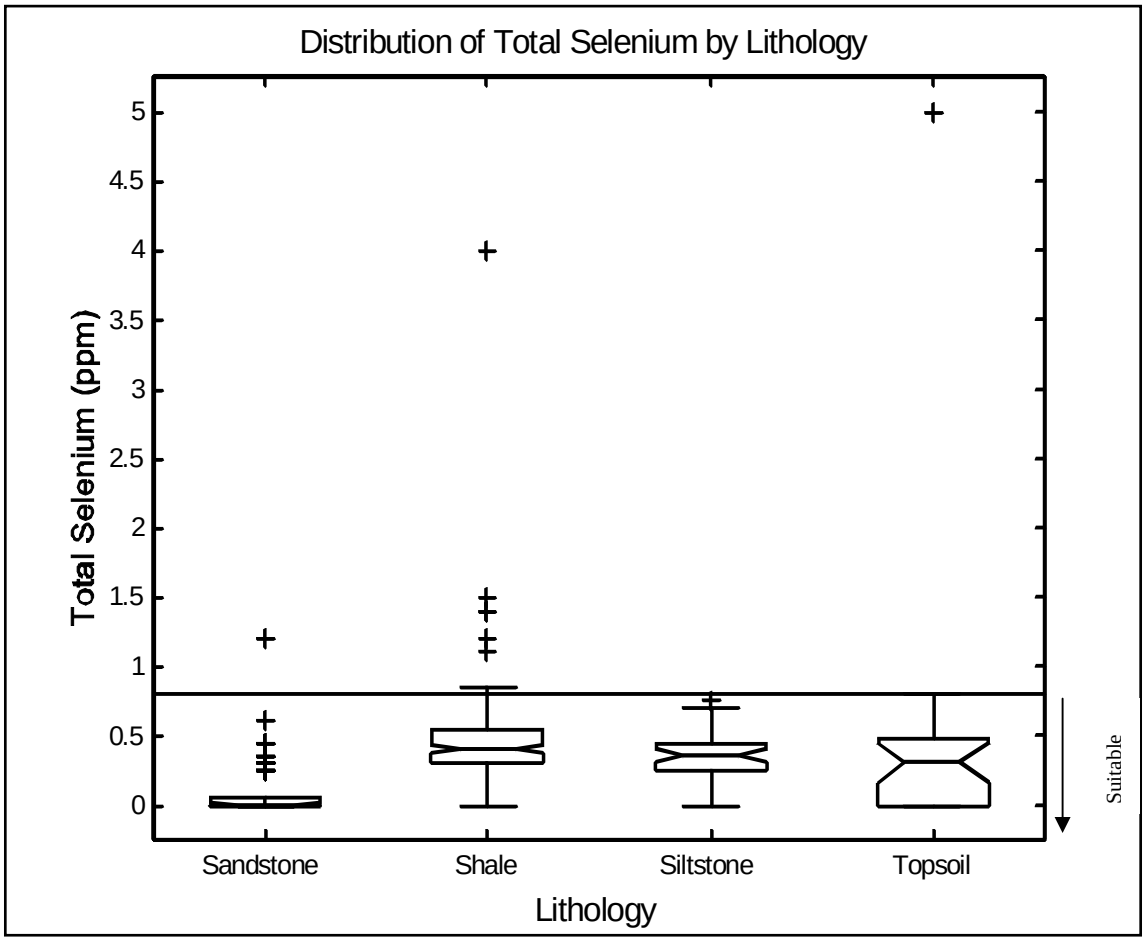

Figure 14. **Box and whisker plots of total selenium by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

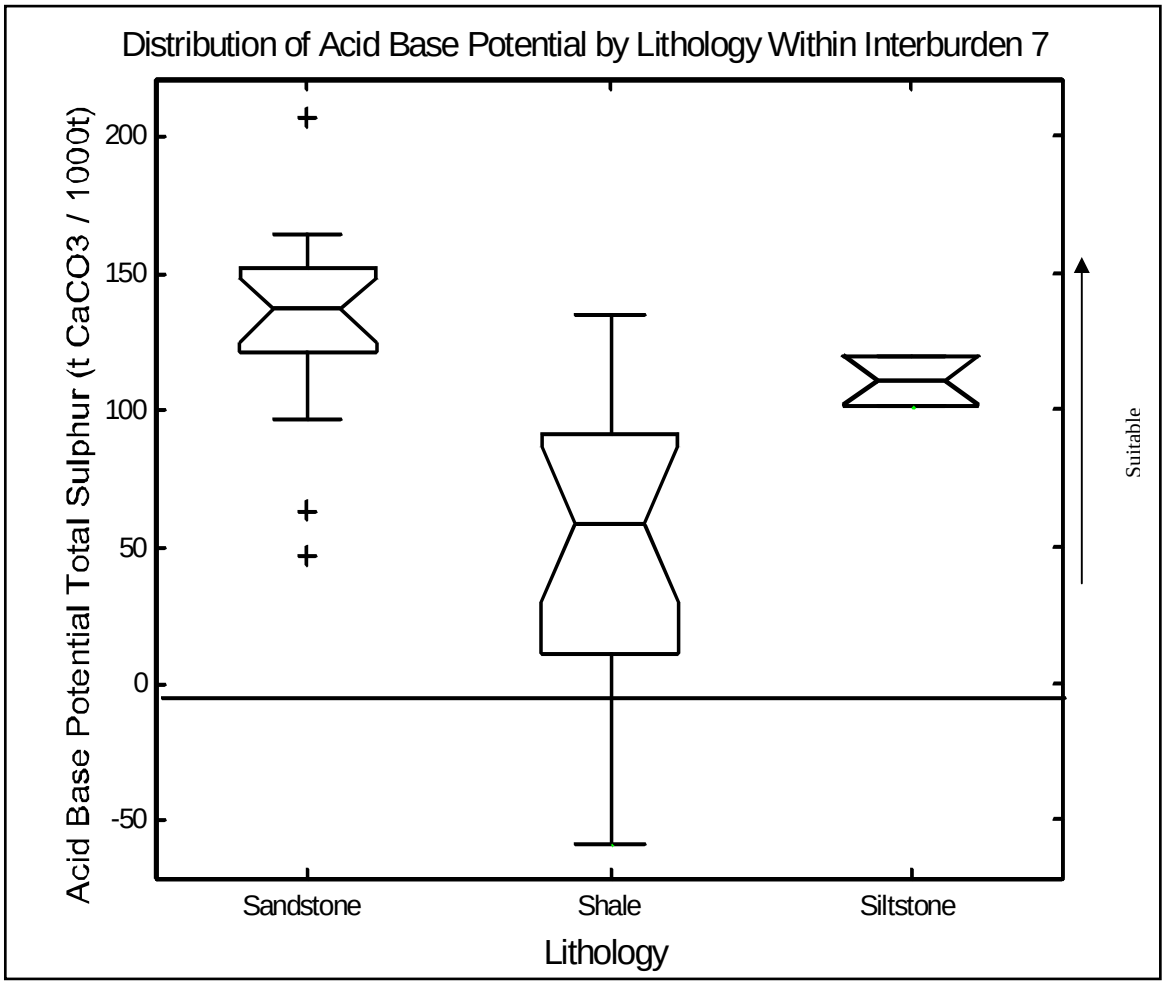

Figure 15. **Box and whisker plots of acid base potential within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

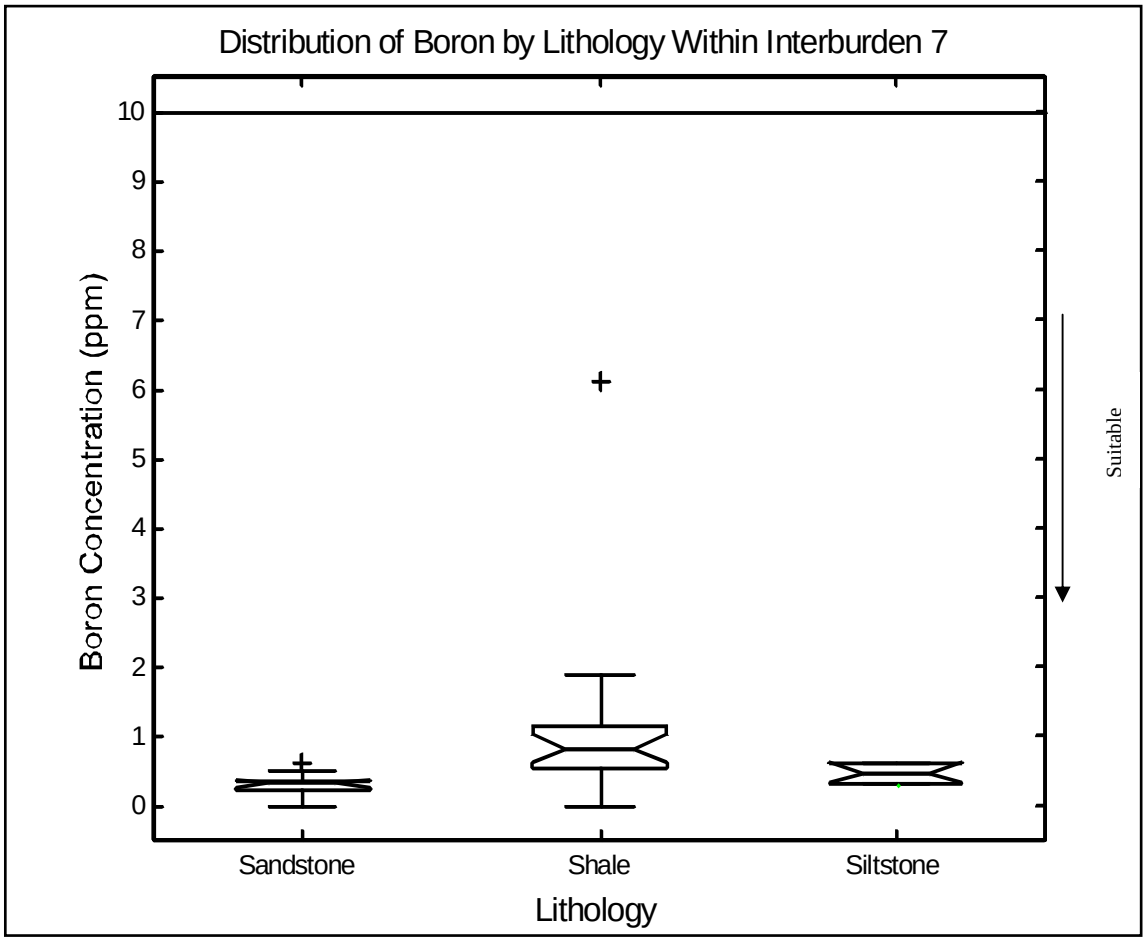

Figure 16. **Box and whisker plots of boron concentration within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

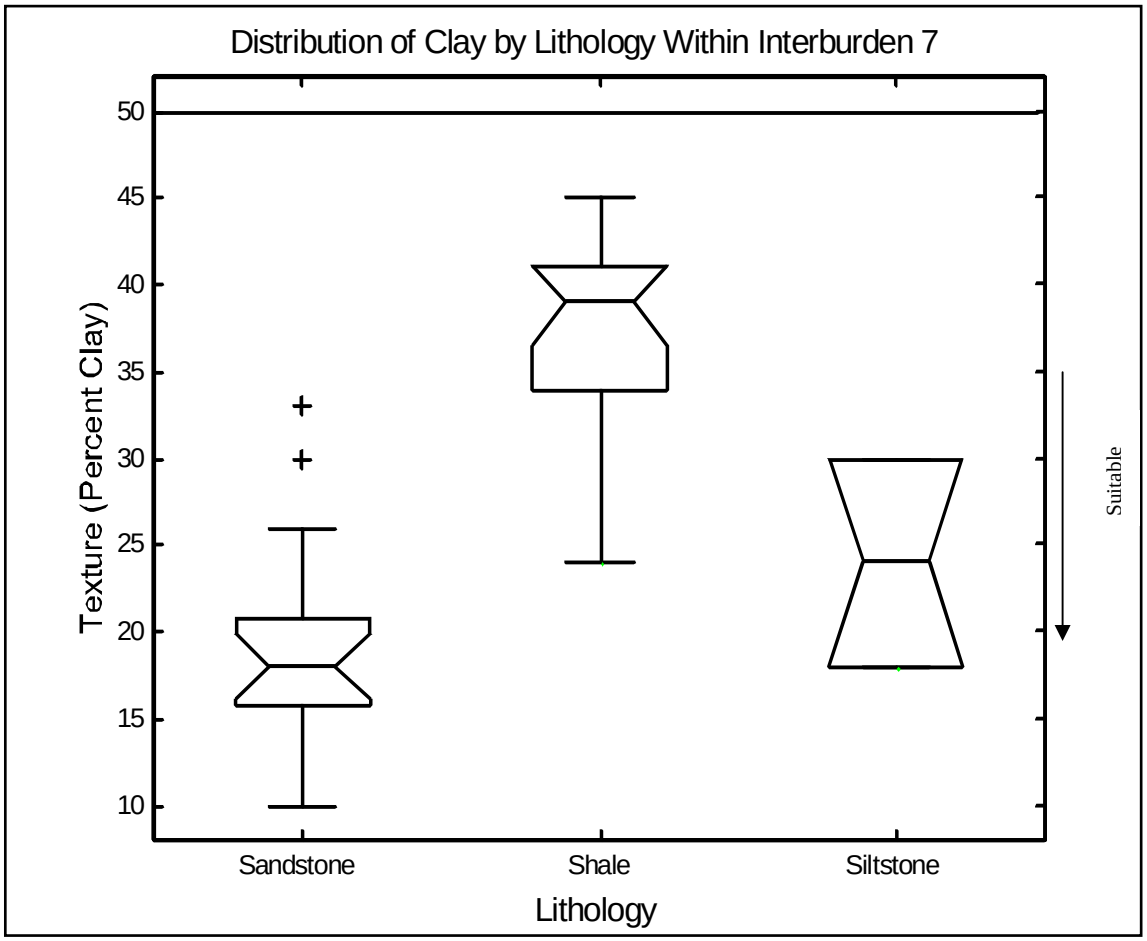

Figure 17. **Box and whisker plots of percent clay within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

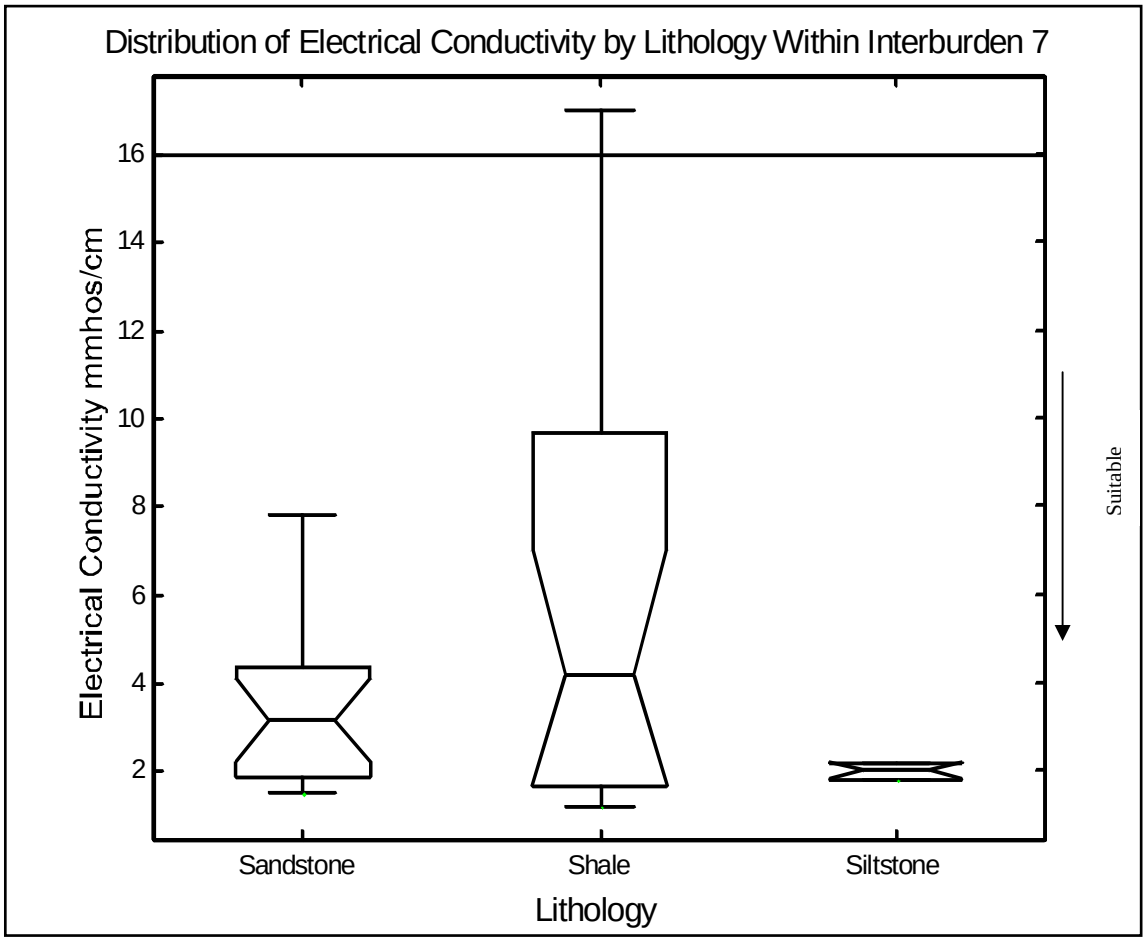

Figure 18. **Box and whisker plots of electrical conductivity within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

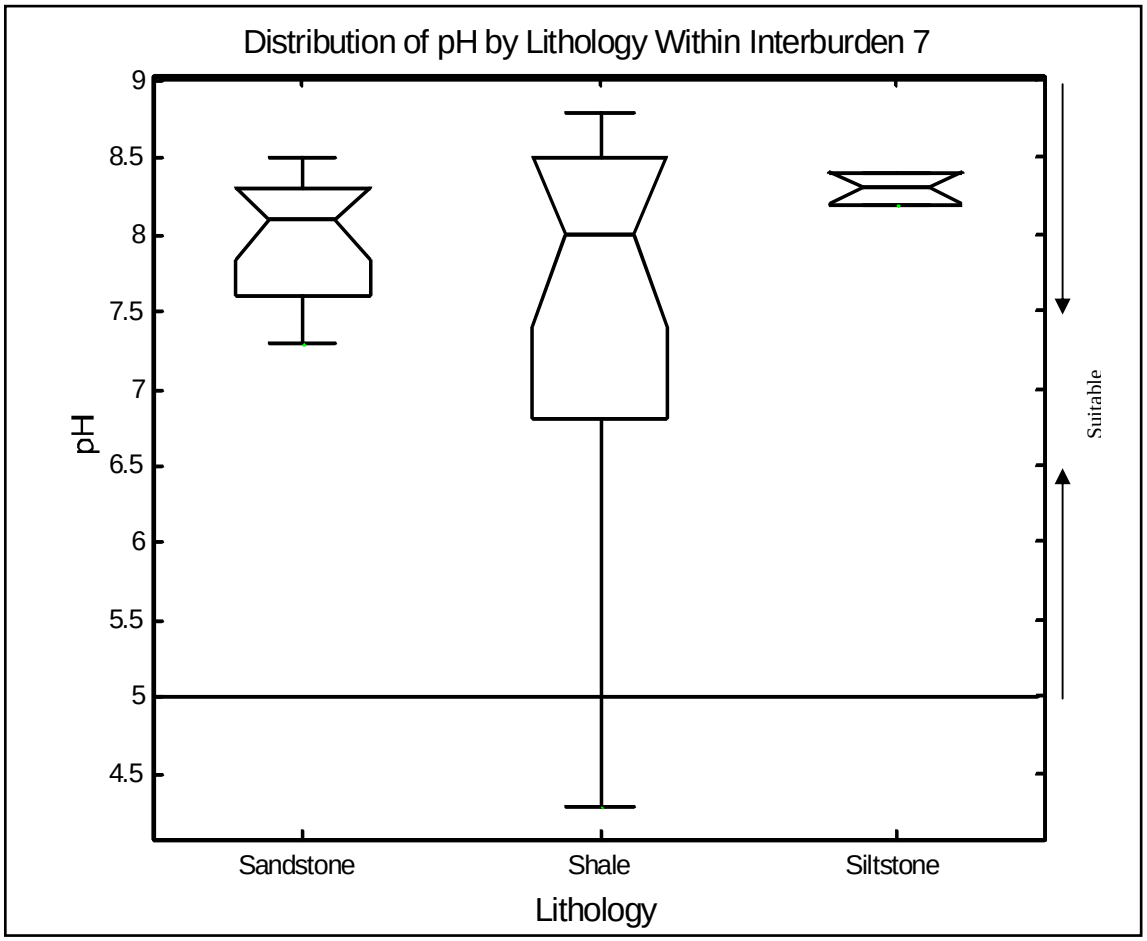

Figure 19. **Box and whisker plots of pH within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

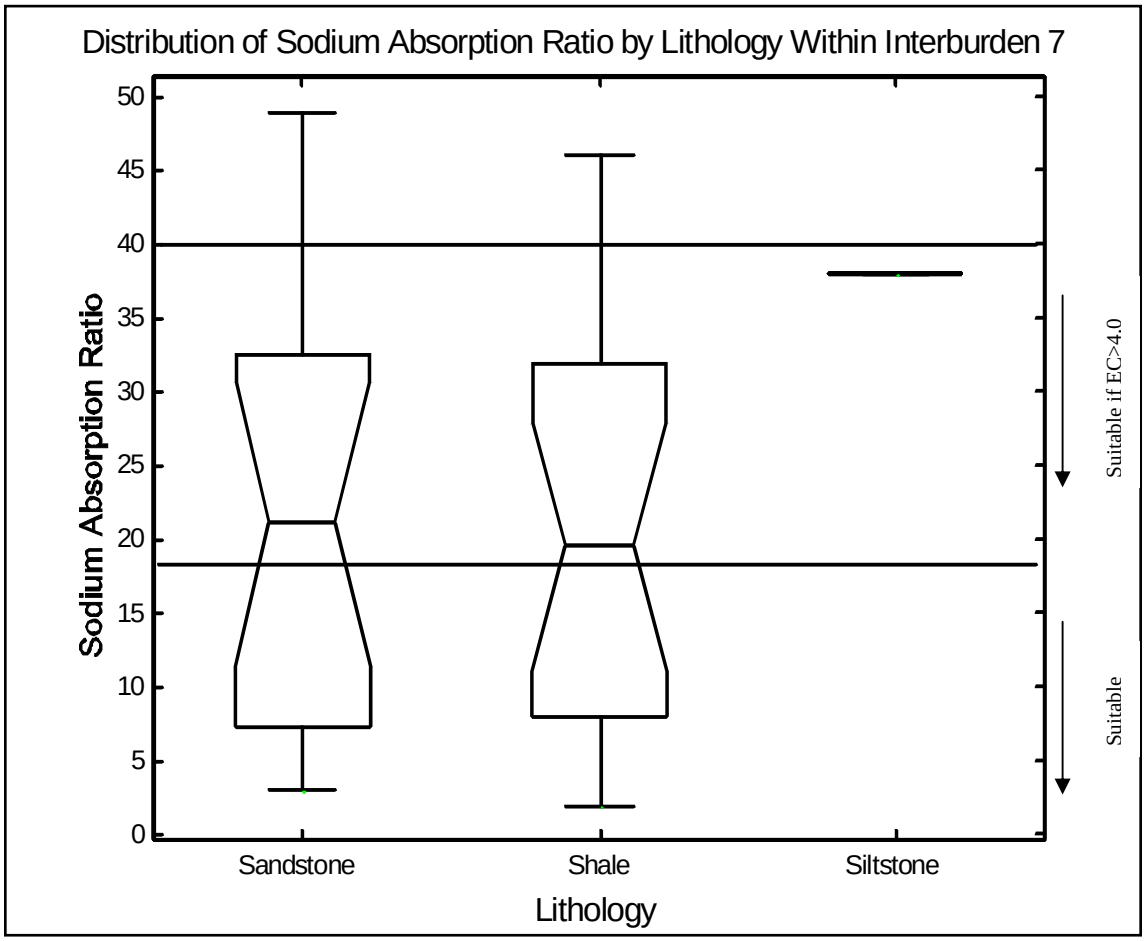

Figure 20. **Box and whisker plots of sodium absorption ratio within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

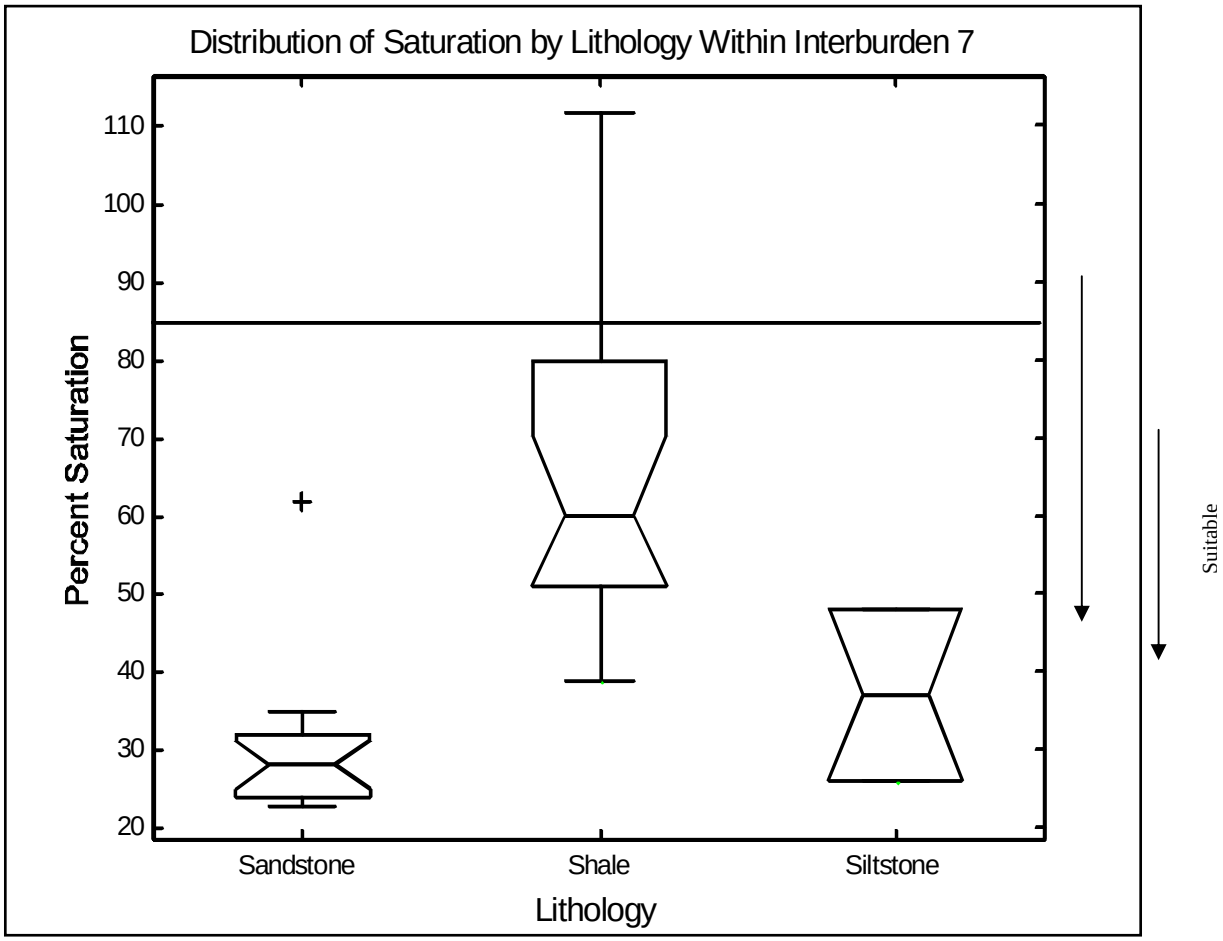

Figure 21. **Box and whisker plots of percent saturation within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

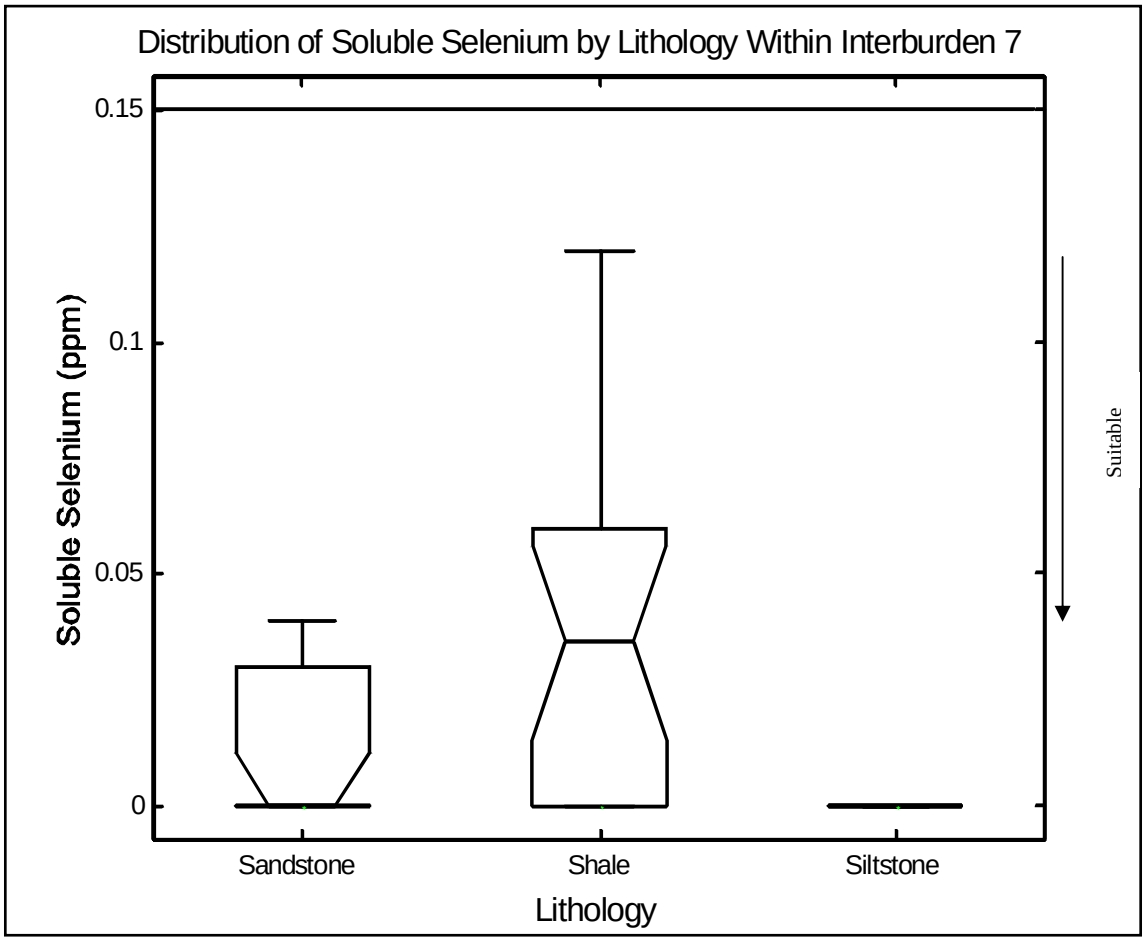

Figure 22. **Box and whisker plots of soluble selenium within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

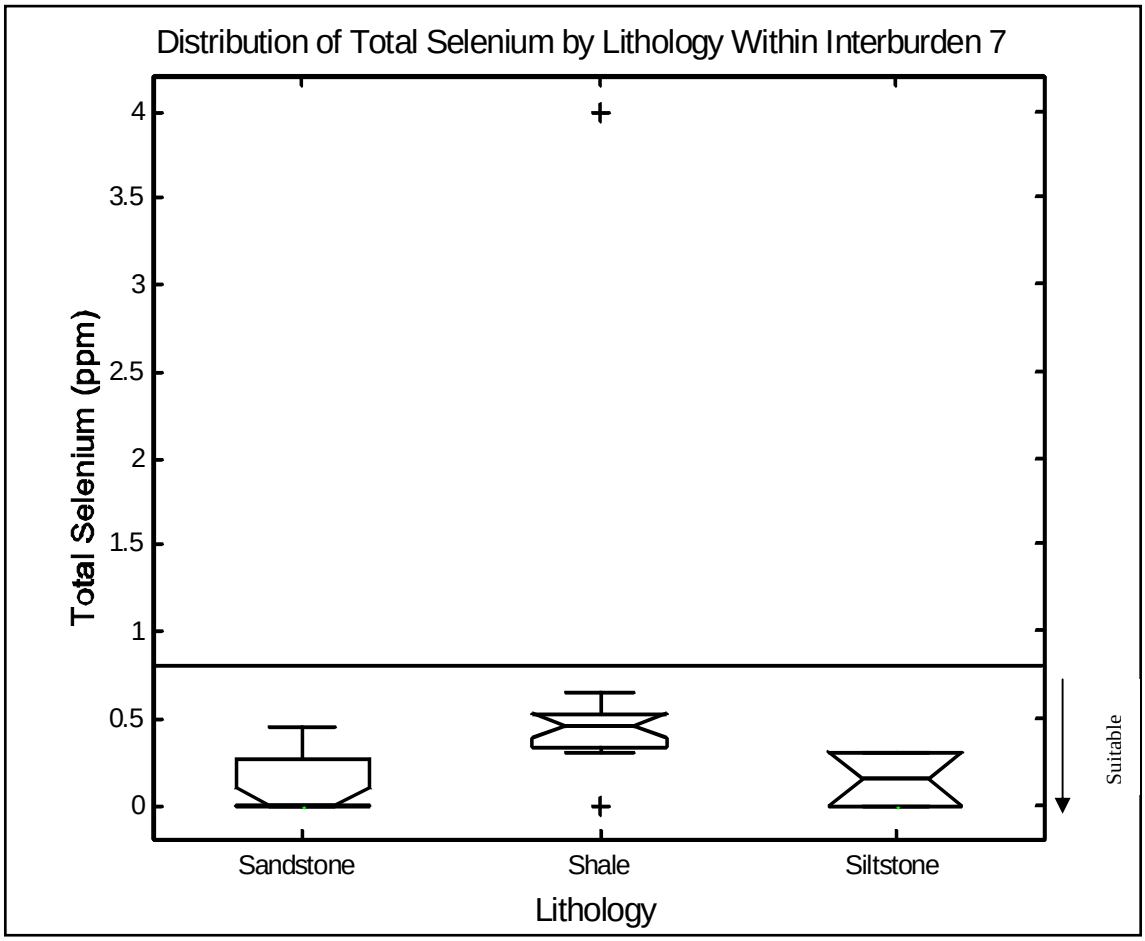

Figure 23. **Box and whisker plots of total selenium within interburden 7 stratified by lithology for all interburden layers. The box represents the 25th and 75th percentiles (1st and 3rd quartiles), the whiskers represent the range of the data up to 1.5 times the length of the box (interquartile range, IQR). Values more than the IQR from the box center are plotted as '+'. The horizontal lines represent the Navajo Mine site specific standard for suitability.**

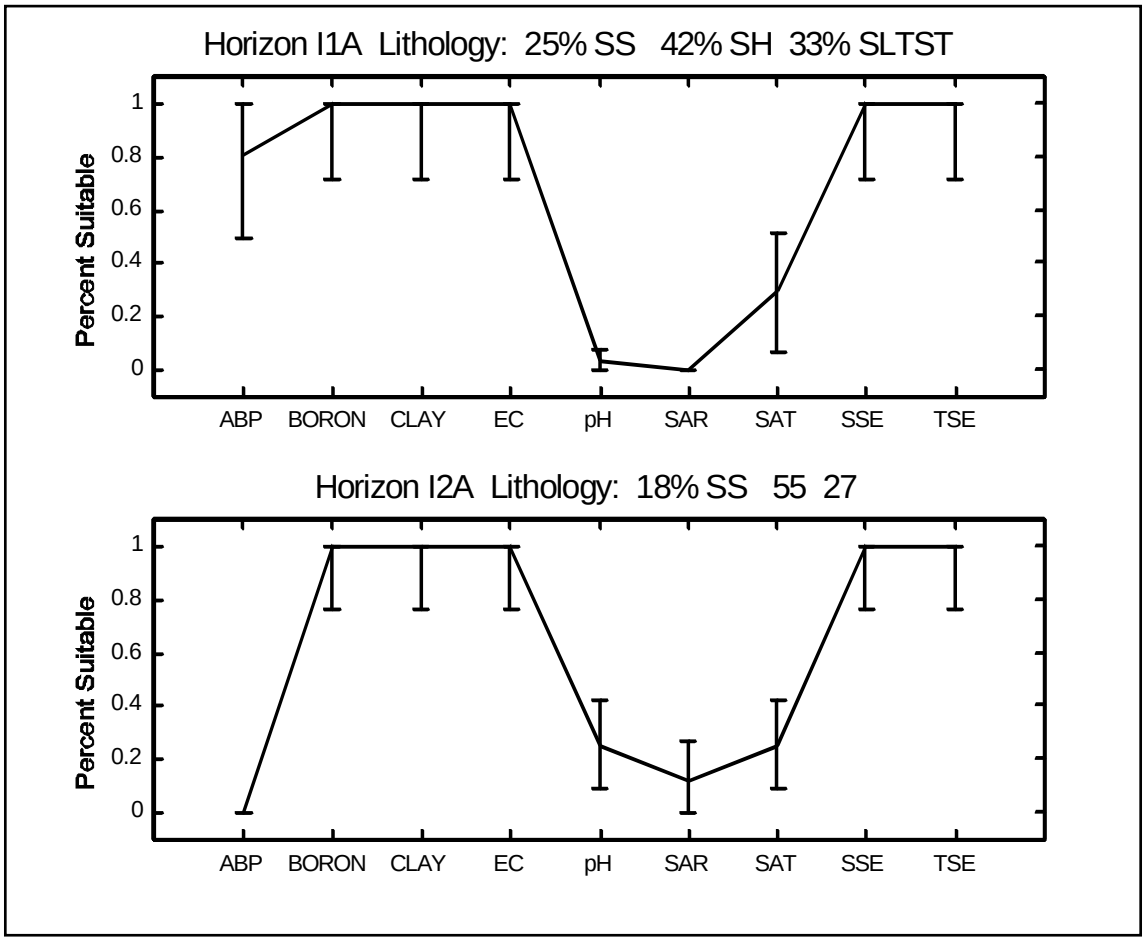

Figure 24. **One-sided 90% confidence intervals on the percent suitable material by horizon based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

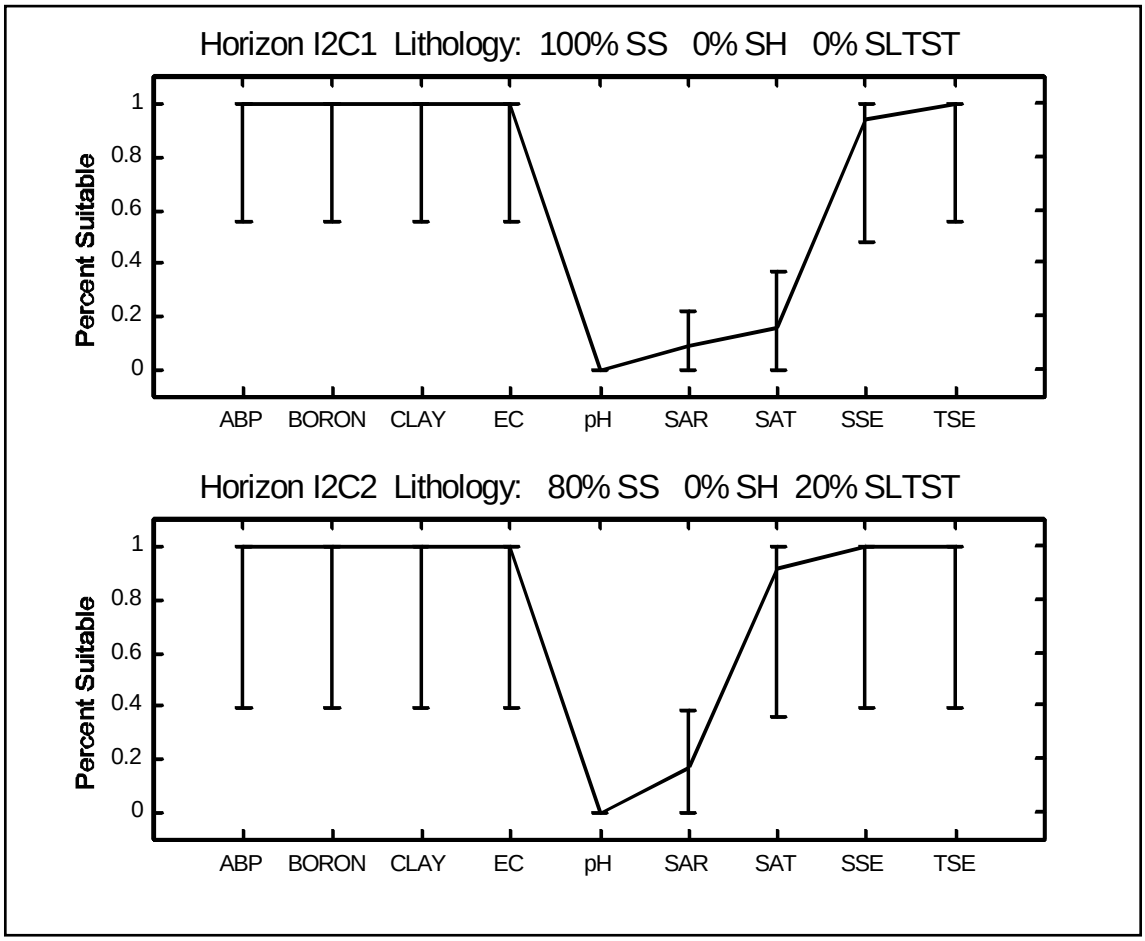

Figure 25. **One-sided 90% confidence intervals on the percent suitable material for the I2C1 and I2C2 horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

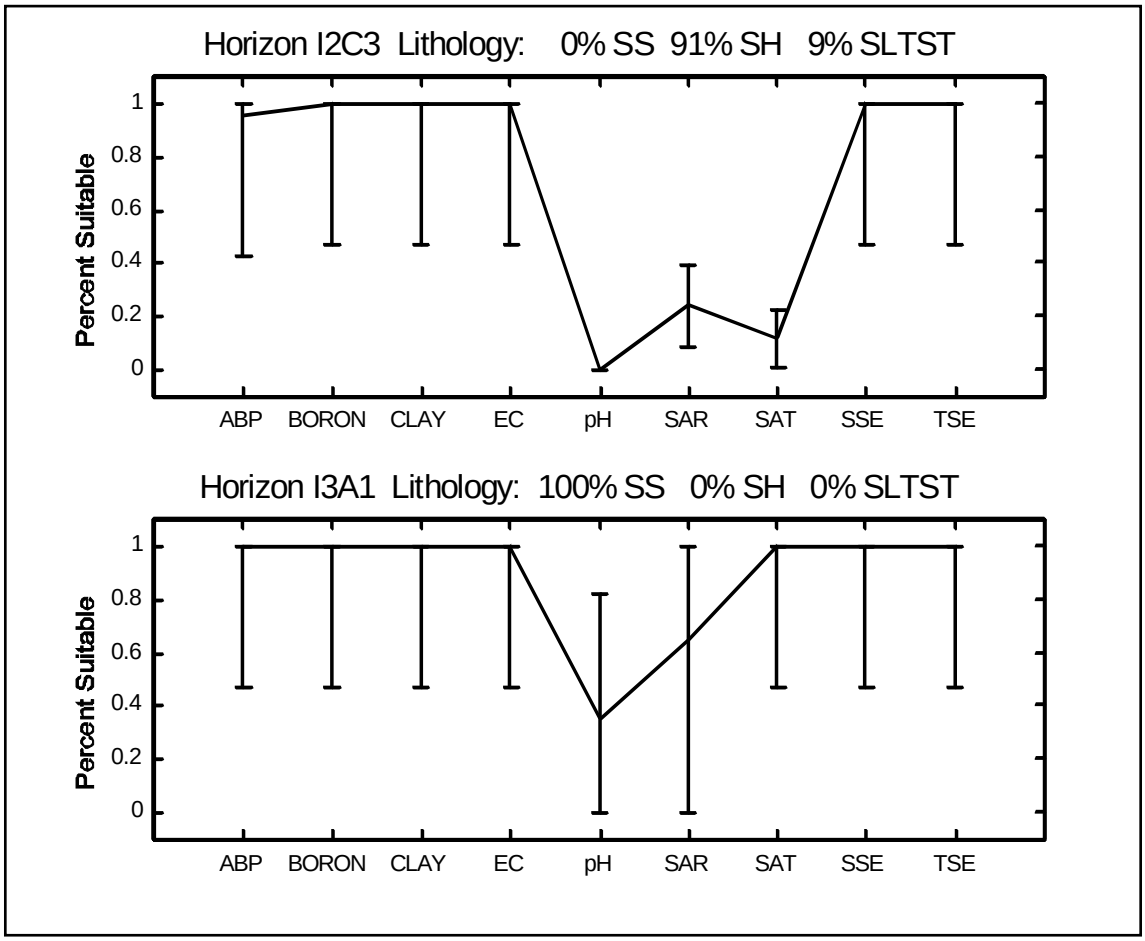

Figure 26. **One-sided 90% confidence intervals on the percent suitable material for the I2C3 and I3A1 horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

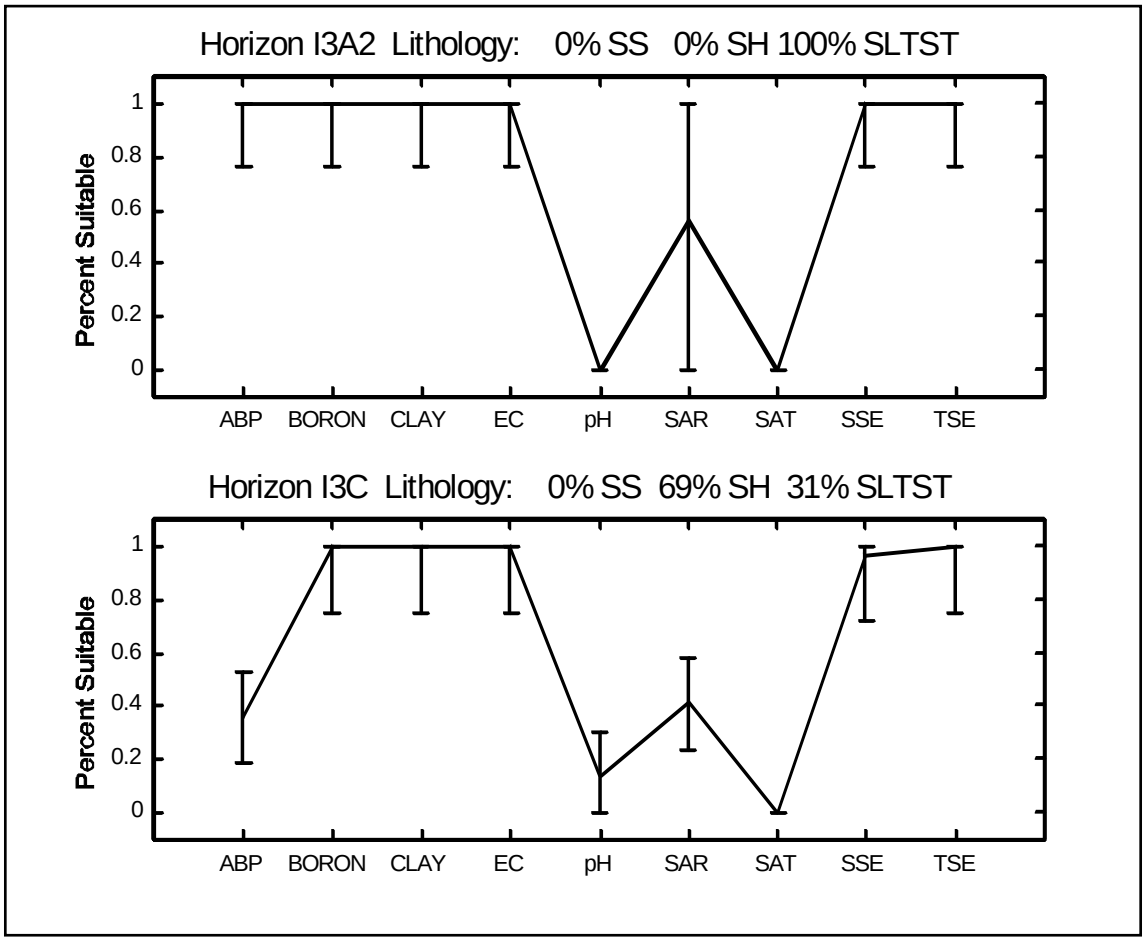

Figure 27. **One-sided 90% confidence intervals on the percent suitable material for the I3A2 and I3C2 horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

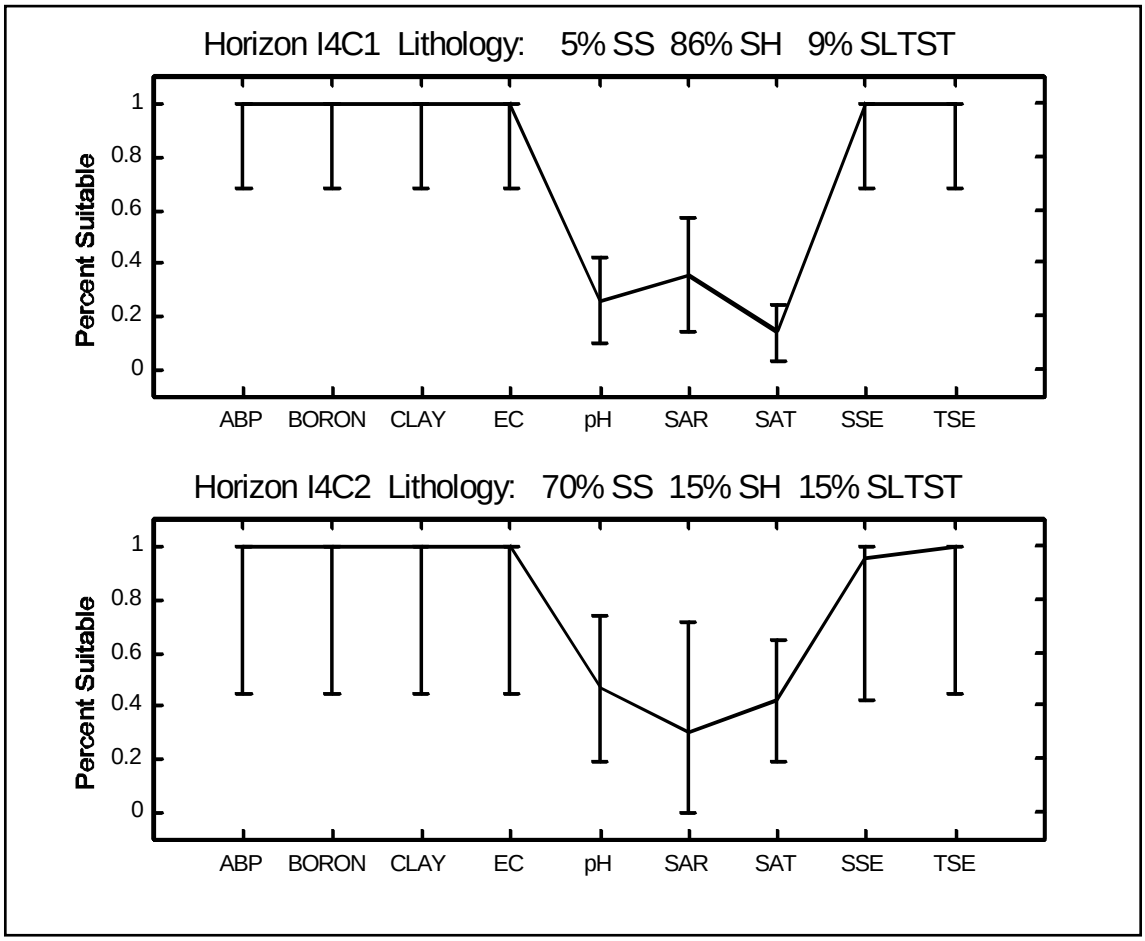

Figure 28. **One-sided 90% confidence intervals on the percent suitable material for the I4C1 and I4C2 horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

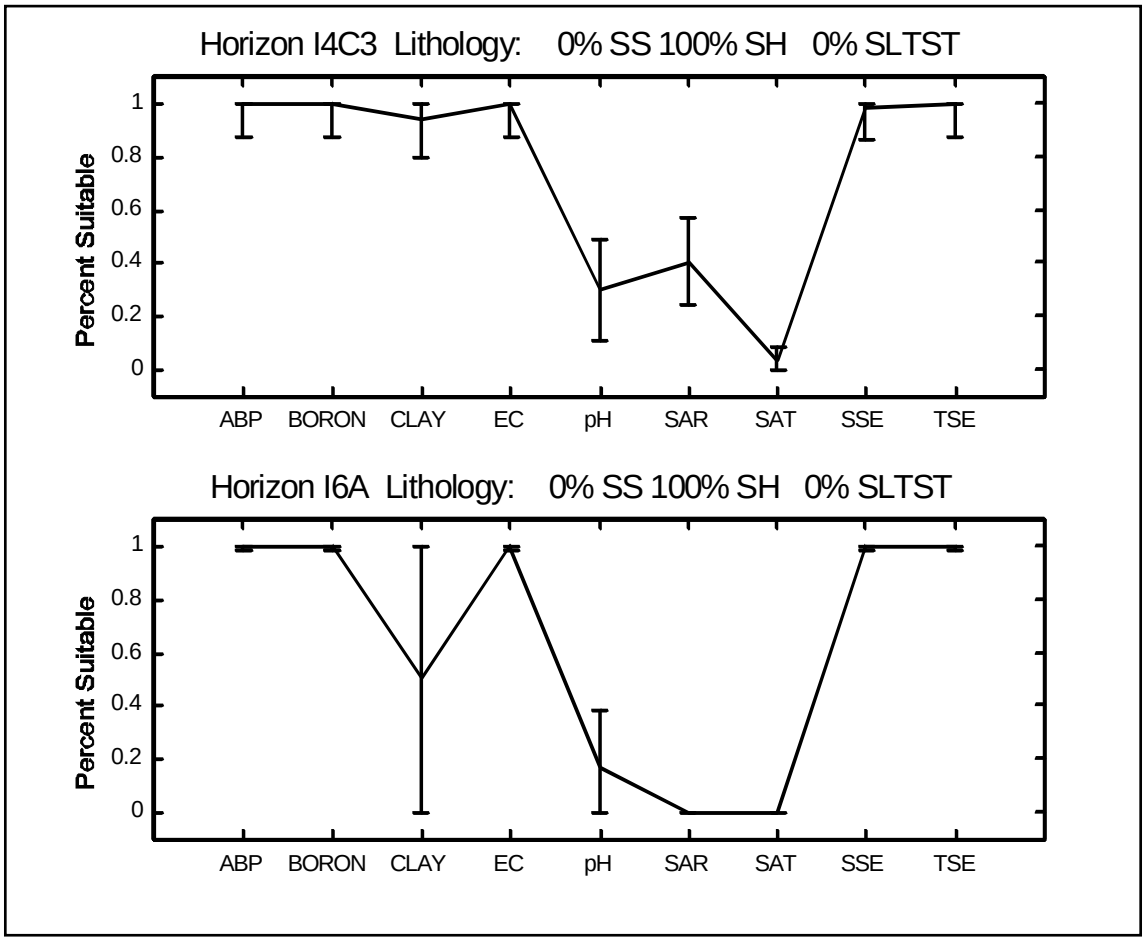

Figure 29. **One-sided 90% confidence intervals on the percent suitable material for the I4C3 and I6A horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

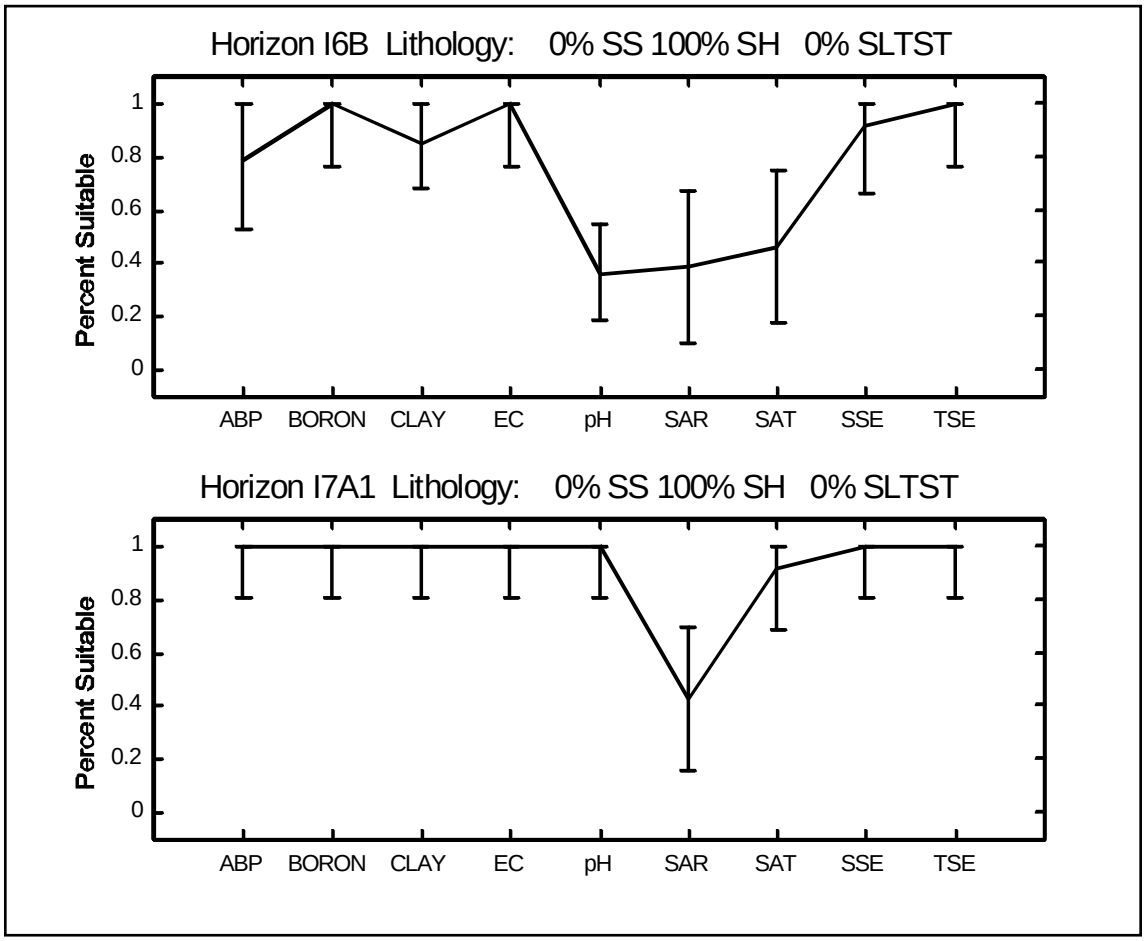

Figure 30. **One-sided 90% confidence intervals on the percent suitable material for the I6B and I7A1 horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

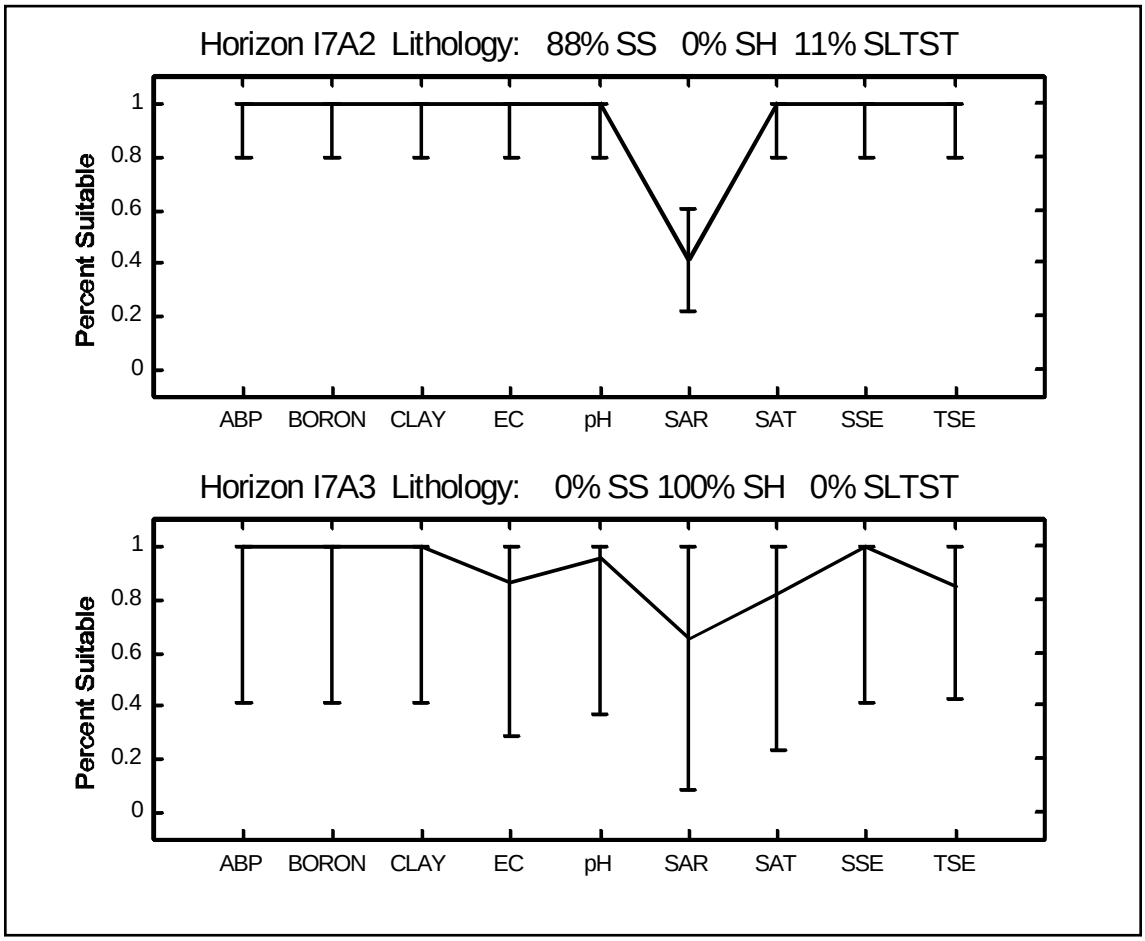

Figure 31. **One-sided 90% confidence intervals on the percent suitable material for the I7A2 and I7A3 horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

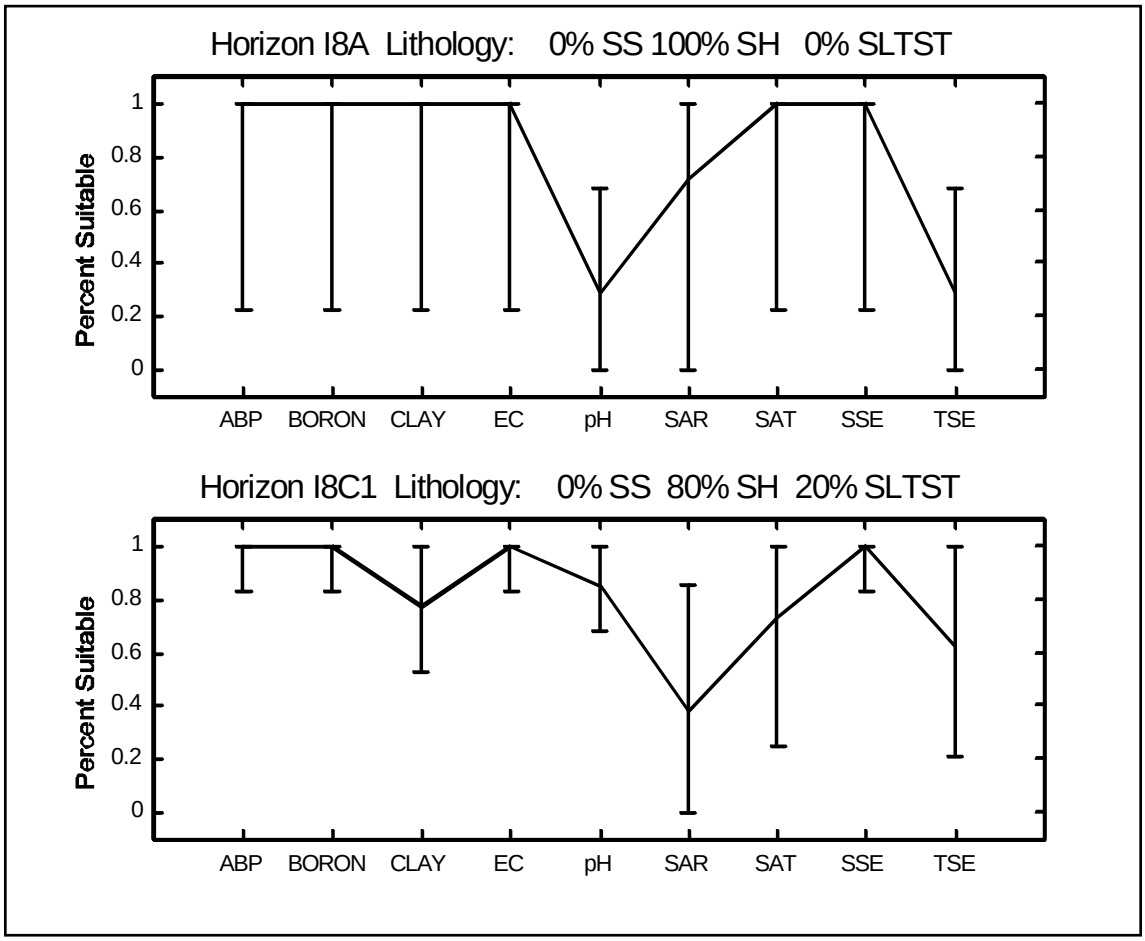

Figure 32. **One-sided 90% confidence intervals on the percent suitable material for the I8A and I8C1 horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

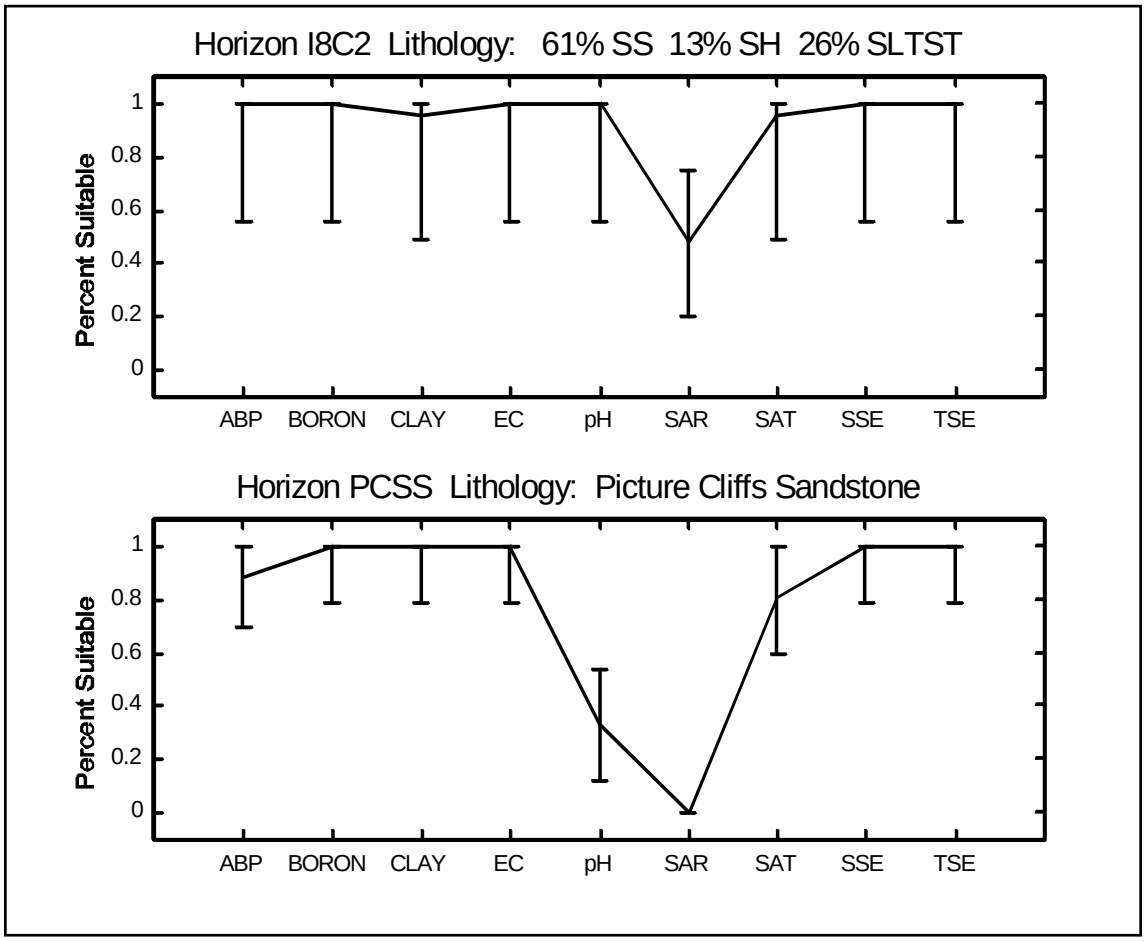

Figure 33. **One-sided 90% confidence intervals on the percent suitable material for the I8C2 and PCSS horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**

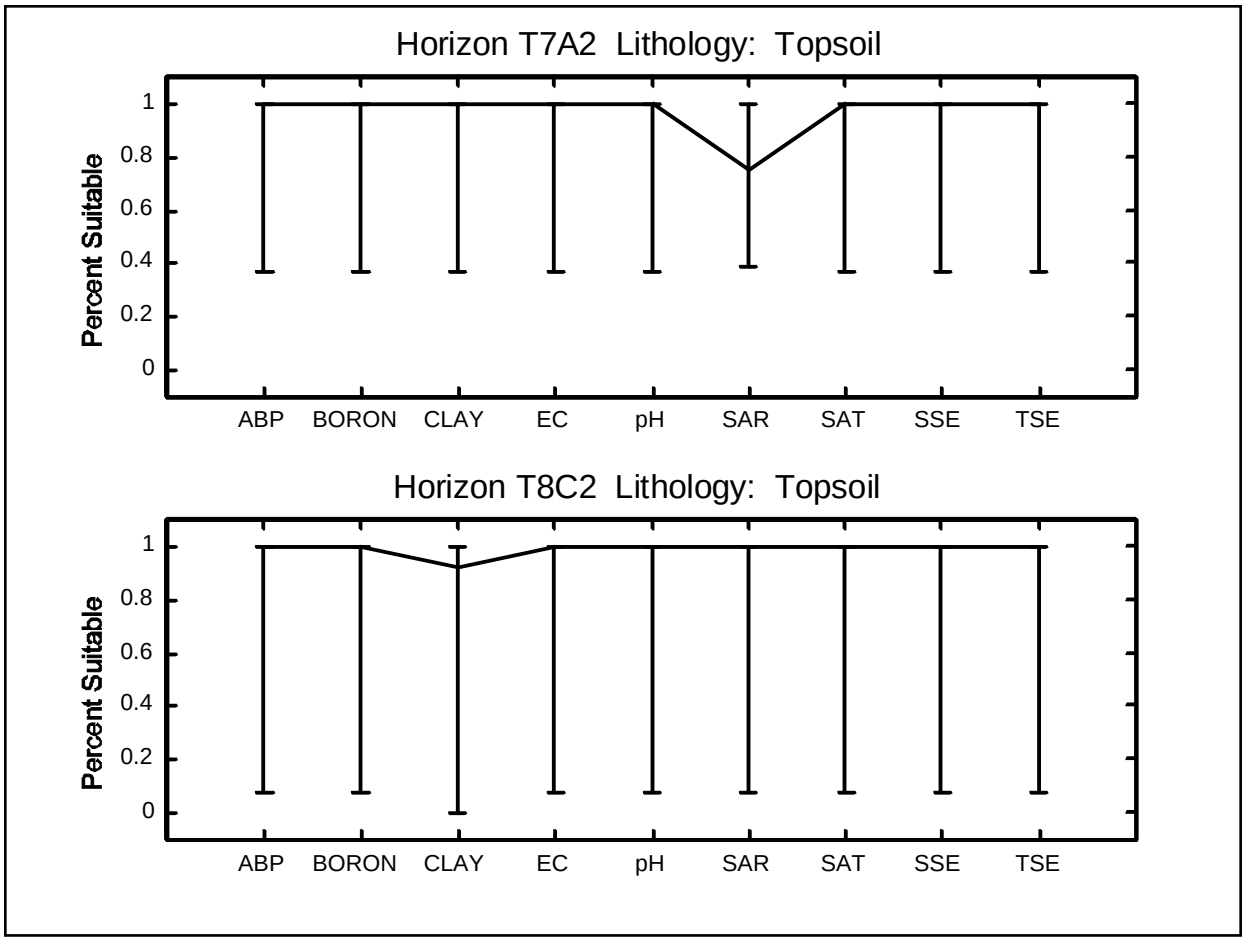

Figure 34. **One-sided 90% confidence intervals on the percent suitable material for the T73A2 and T8C2 horizons based on each analyte, acid base potential (ABP), boron concentration (BORON), texture based on percent clay (CLAY), electrical conductivity (EC), pH, sodium absorption ratio (SAR), soluble selenium (SSE), and total selenium (TSE). The lithologic composition for the horizon is given as percent sandstone (SS), percent shale (SH), and percent siltstone (SLTST). The vertical bar is the 80% confidence interval. The connecting line links estimates of percent of suitable material.**