




ISR Wellfield Background and Restoration Ground Water Quality Data: Collection, Statistical Analysis and Public Access

Elise A. Striz, Ph.D.
Hydrogeologist

Uranium Recovery and Licensing Branch
US Nuclear Regulatory Commission

United States Nuclear Regulatory Commission Official Hearing Exhibit			
In the Matter of:		CROW BUTTE RESOURCES, INC. (License Renewal for the In Situ Leach Facility, Crawford, Nebraska)	
	ASLBP #:	08-867-02-OLA-BD01	Identified: 8/18/2015 Withdrawn: Stricken:
	Docket #:	04008943	
	Exhibit #:	NRC-090-00-BD01	
	Admitted:	8/18/2015	
	Rejected:		
	Other:		

NRC Objective: Protect the public health, safety and the environment

To prevent contamination of ground water at ISR wellfields, NRC regulates source and 11e(2) byproduct fluids to ensure the licensee:

- **Characterizes, Sites and Designs ISR wellfields to ensure conditions are adequate to contain source and byproduct fluids within the wellfield**
- **Establishes background water quality to determine the ground water protection standards (GWPS) for the ore zone , overlying and underlying aquifers**
- **Operates ISR wellfields so that all source and byproduct fluids are contained within the wellfield**
- **Monitors ISR wellfields so that any ground water contamination outside wellfield from source and byproduct fluids is detected and corrected.**
- **Restores ISR wellfields to approved ground water protection standards (GWPS) and demonstrates the restored water quality is stable.**

What are the GWPS that must be established before operation and met after restoration of an ISR wellfield?

NRC Regulatory Information Summary RIS 90-05.

Licensees and applicants must commit to achieve the ground water quality standards in 10 CFR Part 40, Appendix A Criterion 5B (5) for all restored aquifers which conforms to the standards promulgated by EPA in 40 CFR Part 192 Subpart D 192.32 (2).

These standards state the concentration of a hazardous constituent (Criterion 13) must not exceed :

- (a) the Commission approved background concentration of that constituent in ground water;***
- (b) the respective value in the table in paragraph 5C if the constituent is listed in the table and if the background level of the constituent is below the value listed or;***
- (c) an alternative concentration limit established by the Commission.***

I. ISR Wellfield Background Ground Water Quality Collection

What ground water quality is collected in the ISR wellfield?

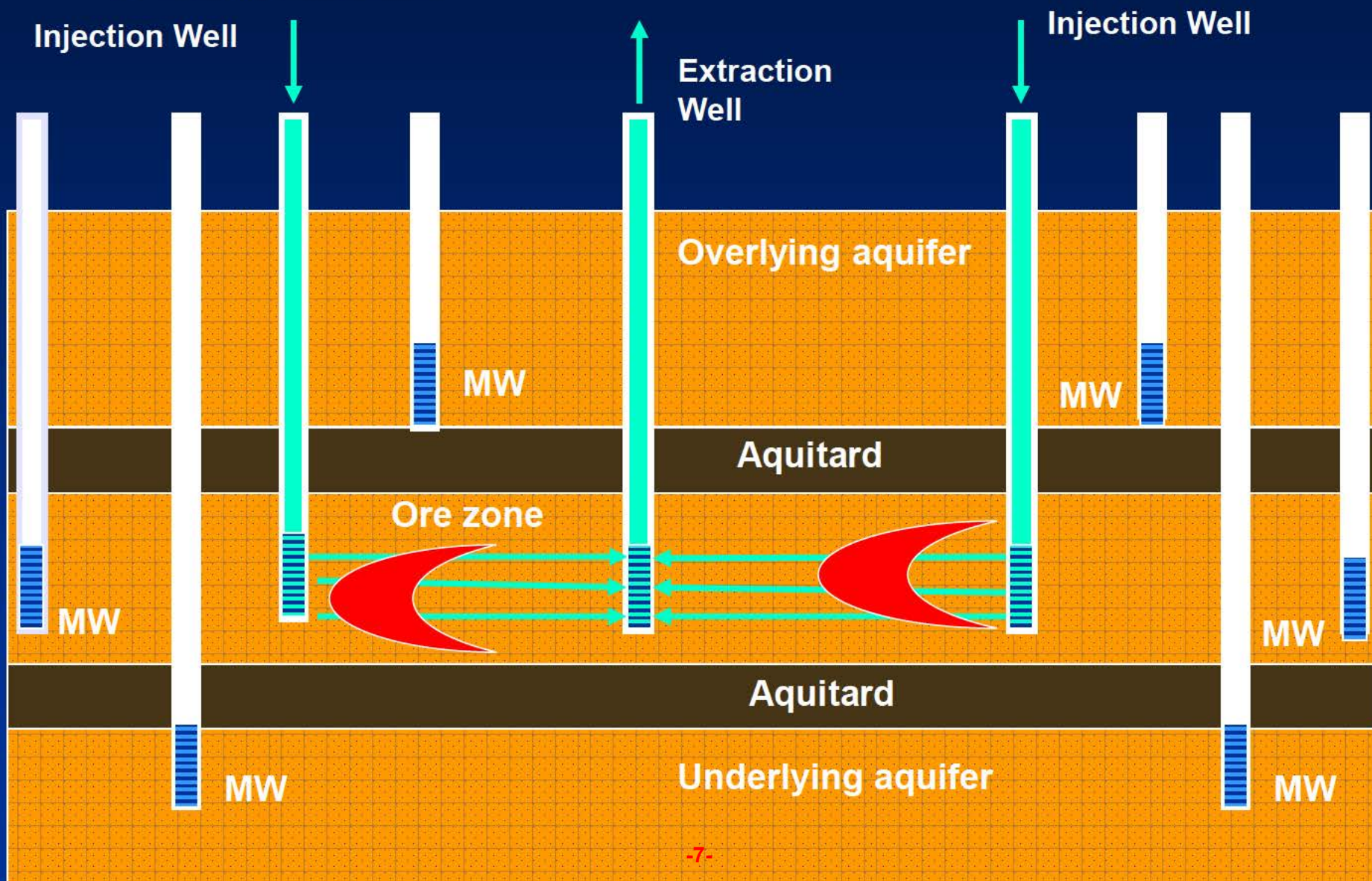
- **The background water quality of all constituents of concern (COC) in the ore zone aquifer and ore zone perimeter ring monitoring wells in the ISR wellfield.**
- **The background water quality of all constituents of concern (COC) in the overlying and underlying aquifers in the ISR wellfields.**

Where is the ground water quality collected before operation of an ISR wellfield?



Example of ISR Wellfield

ISR Extraction, Injection and Overlying, Underlying and Perimeter Monitoring Wells



How many samples are collected to assess the background ground water quality in an ISR wellfield?

- **Production Ore Zone Aquifer (s) - 4 samples/well, at least 2 weeks apart**
- **Perimeter Monitoring Ring Wells- 4 samples/well, at least 2 weeks apart**
- **Overlying Aquifer(s) - 4 samples/well, at least 2 weeks apart**
- **Underlying Aquifer(s) –4 samples/well, at least 2 weeks apart**
- **Example: For a forty acre ISR wellfield, the production ore zone aquifer would have 40 samples for each parameter (1 well/4 acres basis).**

What parameters are measured to establish the background ground water quality in an ISR wellfield?

Typically measure NUREG- 1569 Table 2.7.3-1 parameters in each sample, unless non-detect in first two samples

Table 2.7.3-1. Typical Baseline Water Quality Indicators to be Determined During Pre-operational Data Collection		
A. Trace and Minor Elements		
Arsenic	Iron	Selenium
Barium	Lead	Silver
Boron	Manganese	Uranium
Cadmium	Mercury	Vanadium
Chromium	Molybdenum	Zinc
Copper	Nickel	
Fluoride	Radium-226 [@]	
B. Common Constituents		
Alkalinity	Chloride	Sodium
Bicarbonate	Magnesium	Sulfate
Calcium	Nitrate	
Carbonate	Potassium	
C. Physical Indicators		
Specific Conductivity*		Total Dissolved Solids [#]
pH*		
D. Radiological Parameters		
Gross Alpha [†]	Gross Beta	
*Field and Laboratory determination. #Laboratory only. †Excluding radon, radium, and uranium. @ If site initial sampling indicates the presence of Th-232 then Ra-226 should be considered in the base line sampling or an alternative may be proposed.		

II. Statistical Analysis of ISR Wellfield Water Quality

How should the ISR wellfield water quality be analyzed?

- **Apply appropriate statistics to ground water quality measurements**
 - **Graphical analysis of data distribution to assess if water quality parameter is from same population in a wellfield or different water zones (different sample populations).**
 - **Graphical and other tests for same population and outlier determination**
 - **General statistics- mean, median, standard deviation, etc.**
 - **Goodness of Fit (GOF) tests to select appropriate probability distribution**
 - **Upper Tolerance Limits (UTLs) and upper percentiles**
 - **Upper Confidence Limits (UCLs) of the Mean**
- **Accepted statistical methods can be found in EPA-530-R-09-007, "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance," March 2009.**

What software applications are useful for statistical analysis of ISR wellfield ground water quality?



ProUCL 4.1.00

Statistical Software for Environmental Applications
for Data Sets with and without Nondetect
Observations

<http://www.epa.gov/osp/hstl/tsc/software.htm>

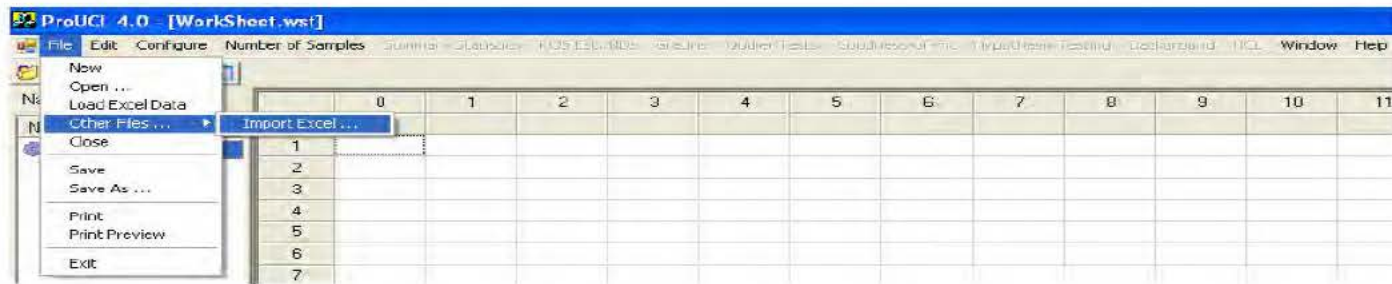
3

Free Download ProUCL 4.1 (<http://www.epa.gov/osp/hstl/tsc/software.htm>),

Free Webinar Training can be found at http://www.clu-in.org/conf/tio/ProUCLBasic_030911/prez/1280x1024/ppframe.cfm?date=504&simul=1

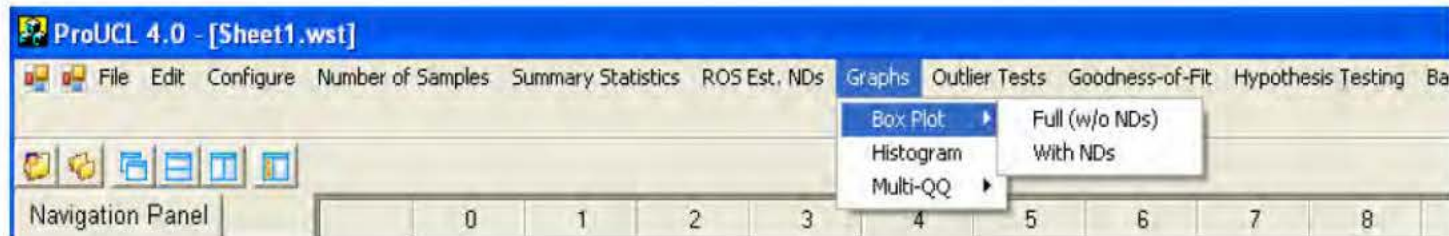
ProUCL 4.1 Features User Friendly Spreadsheet Interface

Import Excel files (Excel 2003 *.xls format) and export output files



Possible Error Messages:

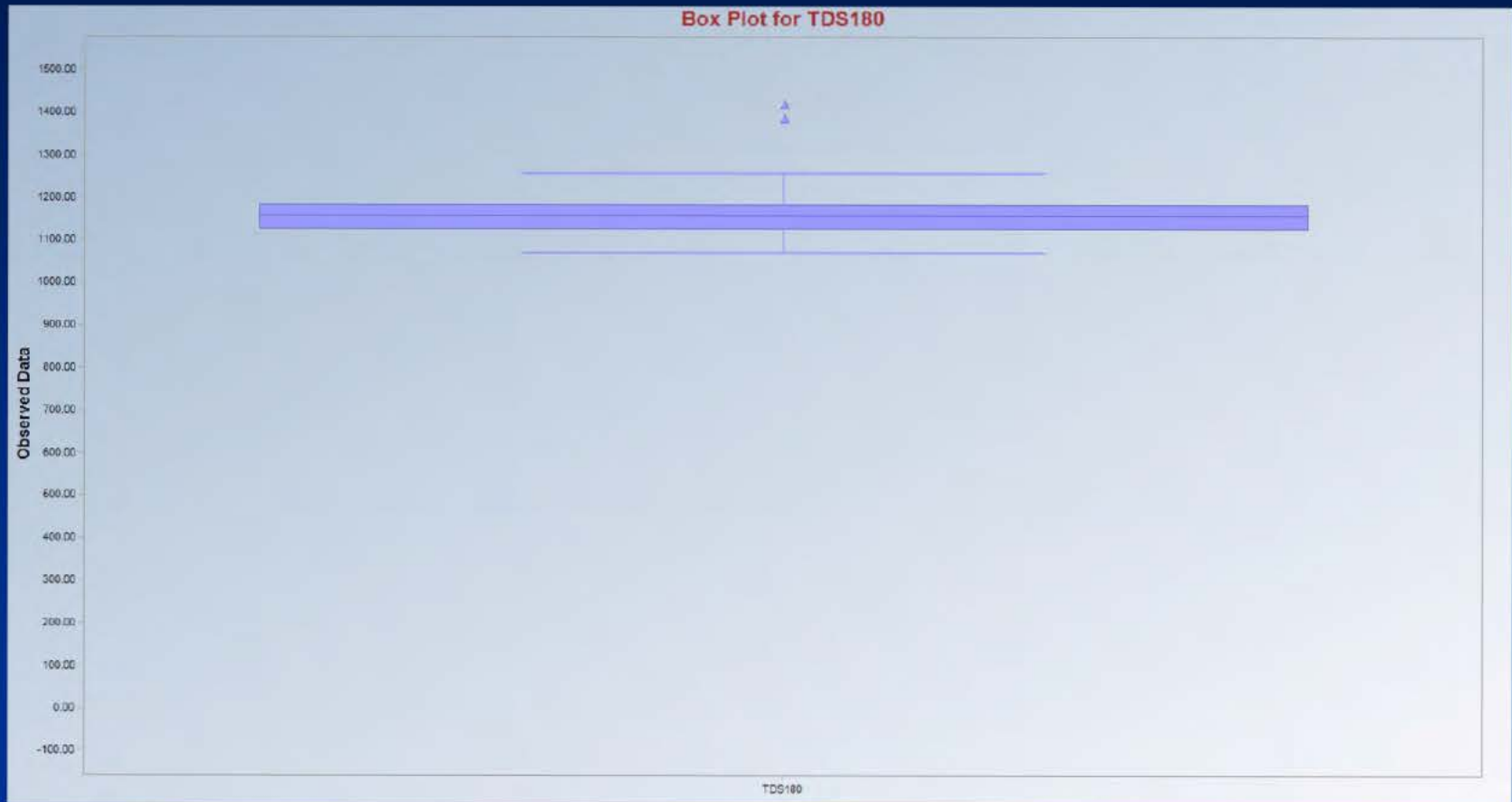
Spreadsheet pull-down menus to perform statistical analyses



Pro UCL 4.1 Example

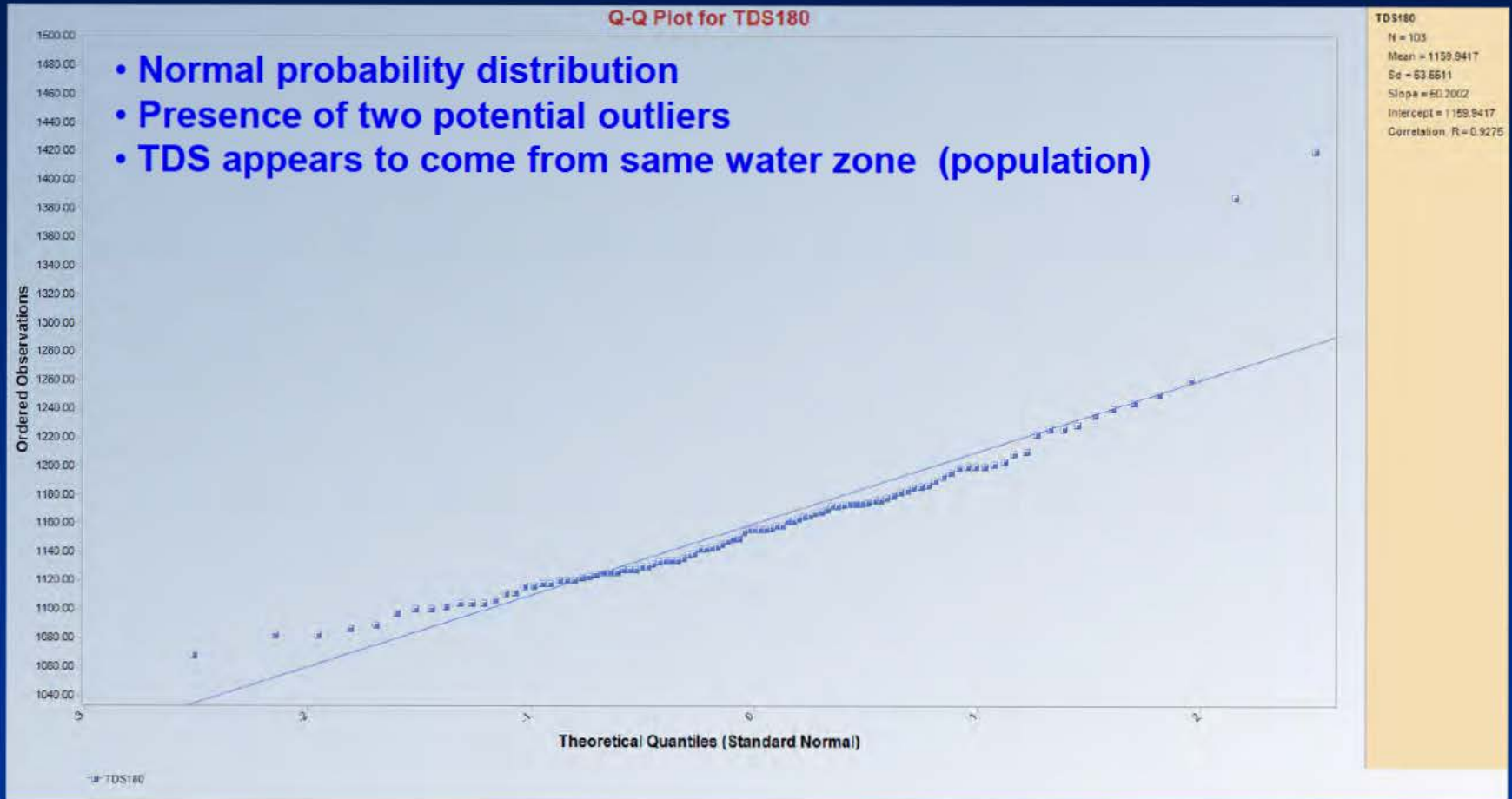
ISR Wellfield Ore Zone TDS data set

Box plot to demonstrate distribution, median and presence of outliers



- Apparent normal probability distribution
- Presence of two potential outliers
- TDS appears to come from same water zone (population)

ProUCL 4.1 Example ISR Wellfield Ore Zone TDS data set QQ plot to demonstrate probability distribution and presence of outliers

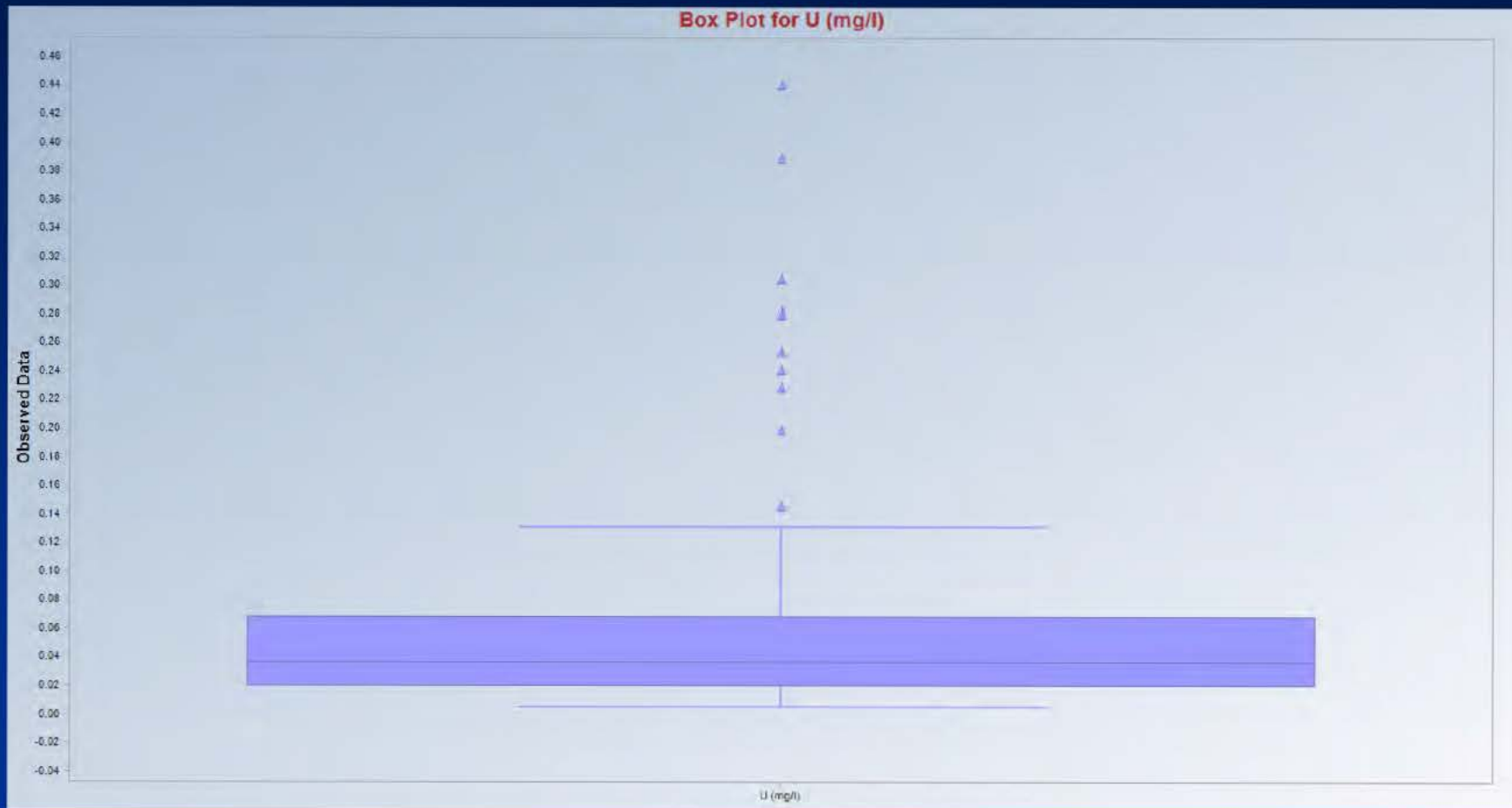


Conclusion - can use normal probability distribution to evaluate outliers, mean , standard deviation, etc. for ISR wellfield TDS

ProUCL 4.1 Example

ISR Wellfield Ore Zone Uranium data set

Box Plot for uranium distribution and outliers

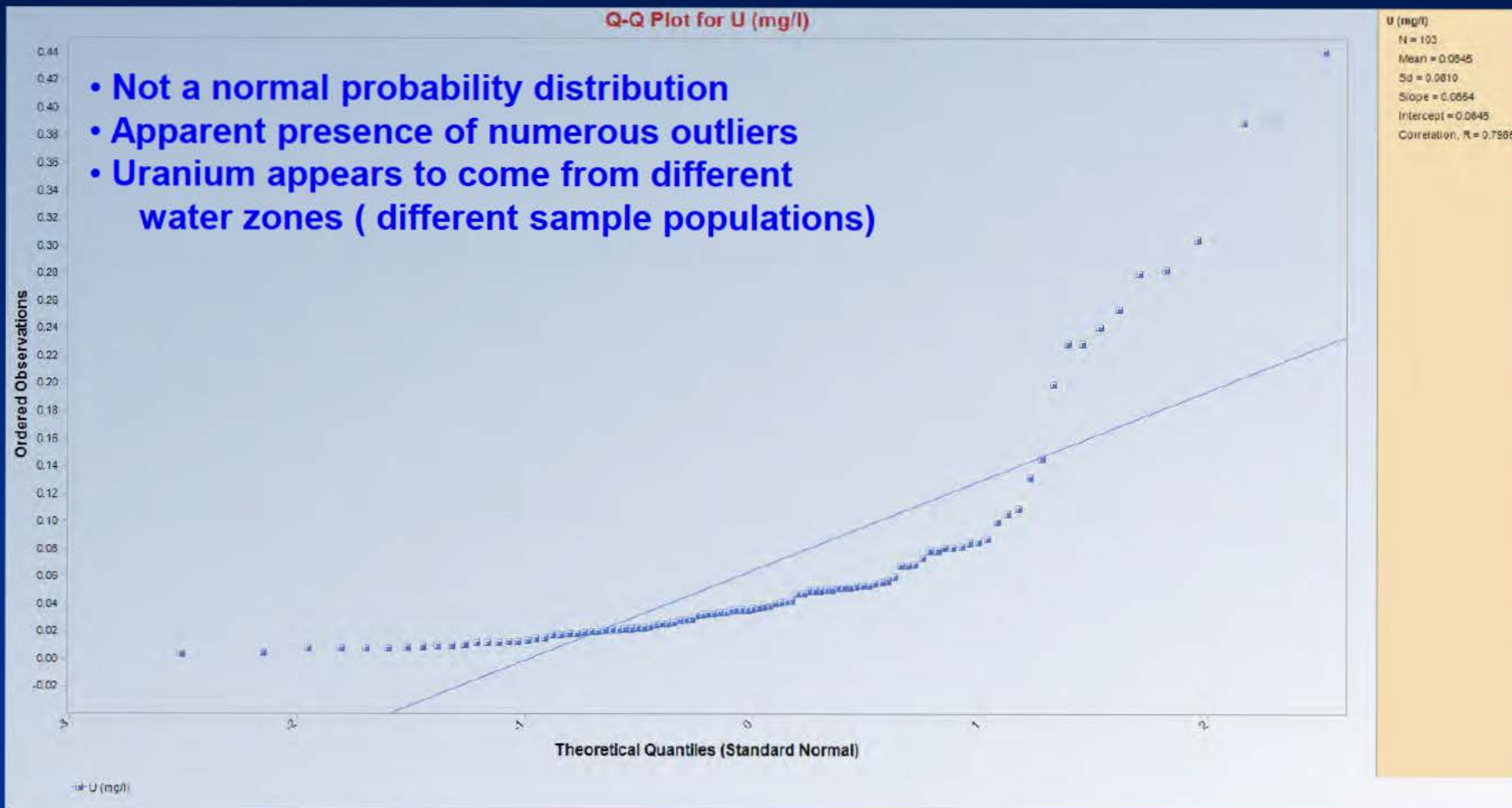


- Uranium data do not appear to follow a normal distribution - data skewed
- Appear to be numerous potential outliers
- Appear to have different water zones (populations)

ProUCL 4.1 Example

ISR Wellfield Ore Zone Uranium data set

QQ plot to demonstrate probability distribution and presence of outliers

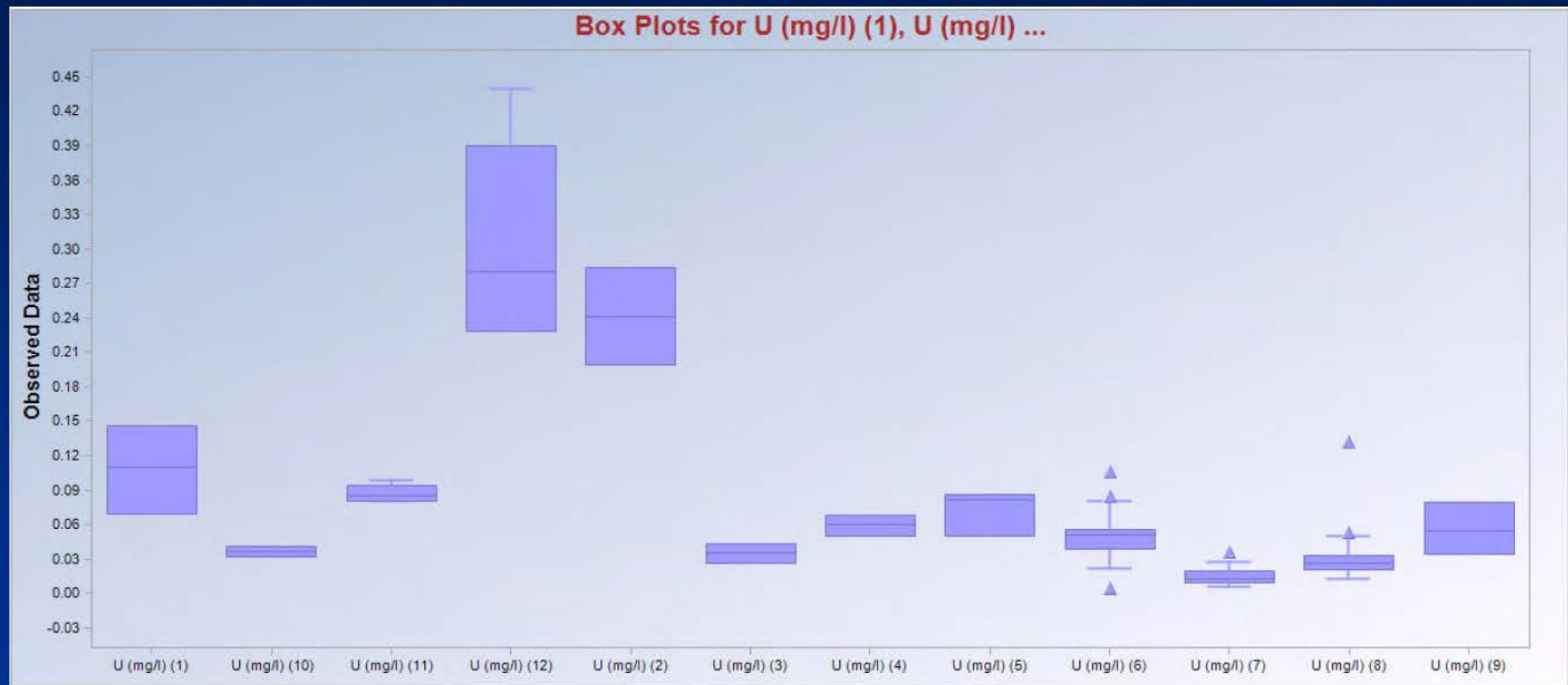


Question – Does that make sense when compared to same TDS data for same ISR Wellfield?

ProUCL 4.1 Example

ISR Wellfield Ore Zone Uranium data set

Box Plot for uranium distribution and outliers for individual wells



Answer: Yes –would expect large heterogeneity in uranium- individual well data show ore zones are naturally heterogeneous in the wellfield

Conclusion- should not use statistics which use normal probability distribution for uranium

ProUCL 4.1 Example ISR Wellfield Ore Zone Uranium data set- General background statistics and probability distribution for uranium

Provides min, max, mean, quartiles,
median, standard deviation, etc.

Provides normal, lognormal and
Gaussian distribution goodness of fit
to choose appropriate probability
distribution

Provides nonparametric statistics for
skewed data and no underlying
distribution

General Background Statistics for Full Data Sets			
User Selected Options			
From File	Baseline ore body.wst		
Full Precision	OFF		
Confidence Coefficient	95%		
Coverage	90%		
Different or Future K Values	1		
Number of Bootstrap Operations	2000		
U (mg/l)			
General Statistics			
Total Number of Observations	103	Number of Distinct Observations	90
Tolerance Factor	1.52		
Raw Statistics		Log-Transformed Statistics	
Minimum	0.0044	Minimum	-5.426
Maximum	0.441	Maximum	-0.819
Second Largest	0.39	Second Largest	-0.942
First Quartile	0.0205	First Quartile	-3.888
Median	0.037	Median	-3.297
Third Quartile	0.0682	Third Quartile	-2.685
Mean	0.0645	Mean	-3.25
Geometric Mean	0.0388	SD	0.978
SD	0.081		
Coefficient of Variation	1.255		
Skewness	2.672		
Background Statistics		Lognormal Distribution Test	
Normal Distribution Test			
Lilliefors Test Statistic	0.285	Lilliefors Test Statistic	0.075
Lilliefors Critical Value	0.0873	Lilliefors Critical Value	0.0873
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
95% UTL with 90% Coverage	0.188	95% UTL with 90% Coverage	0.172
95% UPL (t)	0.2	95% UPL (t)	0.198
90% Percentile (z)	0.188	90% Percentile (z)	0.136
95% Percentile (z)	0.198	95% Percentile (z)	0.194
99% Percentile (z)	0.253	99% Percentile (z)	0.378
Gamma Distribution Test		Data Distribution Test	
k star	1.093	Data appear Lognormal at 5% Significance Level	
Theta Star	0.059		
MLE of Mean	0.0645		
MLE of Standard Deviation	0.0617		
nu star	225.2		
A-D Test Statistic		Nonparametric Statistics	
5% A-D Critical Value	0.78	90% Percentile	0.143
K-S Test Statistic	0.151	95% Percentile	0.253
5% K-S Critical Value	0.0914	99% Percentile	0.388
Data not Gamma Distributed at 5% Significance Level			
Assuming Gamma Distribution		95% UTL with 90% Coverage	
90% Percentile	0.145	95% Percentile Bootstrap UTL with 90% Coverage	0.241
95% Percentile	0.187	95% BCA Bootstrap UTL with 90% Coverage	0.241
99% Percentile	0.284	95% UPL	0.275
		95% Chebyshev UPL	0.419
95% WH Approx. Gamma UPL	0.181	Upper Threshold Limit Based upon IQR	
95% HW Approx. Gamma UPL	0.182		
95% VH Approx. Gamma UTL with 90% Coverage	0.164		
95% HW Approx. Gamma UTL with 90% Coverage	0.164		

ProUCL 4.1 Example ISR Wellfield Uranium Data Set Upper Tolerance Limit (UTL)

Upper Tolerance Limit (UTL)-
A UTL 95%-90% represents a 95%
Upper Confidence Limit (UCL) of the
value of the upper 90th percentile.

WHAT DOES IT MEAN?

This is upper limit of the interval
which contains the measured value
for which 90% of the samples will be
less, 95% of the time (WY Guideline
4 outlier "k test" which is based on
normal distribution).

Lognormal uranium probability
distribution gives UTL_{95%90%}
=0.172 mg/l

Non-parametric – no underlying
distribution gives UTL_{95%90%} =0.241
mg/l

Choice: You can say with 95%
confidence that 90% of the measured
values will be less than 0.241 or 0.172
mg/l.

General Background Statistics for Full Data Sets			
User Selected Options			
From File		Baseline ore body.wst	
Full Precision		OFF	
Confidence Coefficient	95%		
Coverage	90%		
Different or Future K Values	1		
Number of Bootstrap Operations	2000		
U (mg/l)			
General Statistics			
Total Number of Observations	103	Number of Distinct Observations	90
Tolerance Factor	1.52		
Raw Statistics		Log-Transformed Statistics	
Minimum	0.0044	Minimum	-6.426
Maximum	0.441	Maximum	-0.819
Second Largest	0.39	Second Largest	-0.942
First Quartile	0.0205	First Quartile	-3.888
Median	0.037	Median	-3.297
Third Quartile	0.0682	Third Quartile	-2.685
Mean	0.0645	Mean	-3.25
Geometric Mean	0.0388	SD	0.978
SD	0.081		
Coefficient of Variation	1.255		
Skewness	2.672		
Background Statistics		Lognormal Distribution Test	
Normal Distribution Test			
Lilliefors Test Statistic	0.285	Lilliefors Test Statistic	0.075
Lilliefors Critical Value	0.0873	Lilliefors Critical Value	0.0873
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
95% UTL with 90% Coverage	0.188	95% UTL with 90% Coverage	0.172
95% UPL (t)	0.2	95% UPL (t)	0.188
90% Percentile (z)	0.168	90% Percentile (z)	0.136
95% Percentile (z)	0.198	95% Percentile (z)	0.194
99% Percentile (z)	0.253	99% Percentile (z)	0.378
Gamma Distribution Test		Data Distribution Test	
k star	1.093	Data appear Lognormal at 5% Significance Level	
Theta Star	0.059		
MLE of Mean	0.0645		
MLE of Standard Deviation	0.0617		
nu star	225.2		
A-D Test Statistic		Nonparametric Statistics	
5% A-D Critical Value	0.78	90% Percentile	0.143
K-S Test Statistic	0.151	95% Percentile	0.253
5% K-S Critical Value	0.0911	99% Percentile	0.388
Data not Normal at 5% Significance Level			
Assuming Gamma Distribution		95% UTL with 90% Coverage	
90% Percentile	0.145	95% Percentile Bootstrap UTL with 90% Coverage	0.241
95% Percentile	0.187	95% BCA Bootstrap UTL with 90% Coverage	0.241
99% Percentile	0.284	95% UPL	0.275
		95% Chebyshev UPL	0.419
95% WH Approx. Gamma UPL	0.181	Upper Threshold Limit Based upon IQR	0.14
95% HW Approx. Gamma UPL	0.182		
95% WH Approx. Gamma UTL with 90% Coverage	0.164		
95% HW Approx. Gamma UTL with 90% Coverage	0.164		

ProUCL 4.1 Example ISR Wellfield Ore Zone Uranium Data Set Upper Confidence Limit (UCL) of the Mean

Upper Confidence Limit (UCL) of the mean is the upper limit of the interval which contains the mean at some confidence level (e.g. 95%)

Normal Distribution
Students t UCL95 of
the mean = 0.0777 mg/l
(not appropriate)

Lognormal Distribution H-
UCL95 of the mean = 0.0773 mg/l
(not recommended in ProUCL)

Non-parametric Chebyshev UCL
of the mean = 0.0993 mg/l
(recommended for skewed
datasets In ProUCL)

General UCL Statistics for Full Data Sets	
User Selected Options	
From File	Baseline ore body.wst
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000
U (mg/l)	
General Statistics	
Number of Valid Observations	103
Number of Distinct Observations	90
Raw Statistics	Log-transformed Statistics
Minimum 0.0044	Minimum of Log Data -5.425
Maximum 0.441	Maximum of Log Data -0.619
Mean 0.0645	Mean of log Data -3.25
Geometric Mean 0.0388	SD of log Data 0.978
Median 0.037	
SD 0.081	
Std. Error of Mean 0.00798	
Coefficient of Variation 1.255	
Skewness 2.672	
Relevant UCL Statistics	
Normal Distribution Test	Lognormal Distribution Test
Liliefors Test Statistic 0.265	Liliefors Test Statistic 0.075
Liliefors Critical Value 0.0873	Liliefors Critical Value 0.0873
Data not Normal at 5% Significance Level	Data appear Lognormal at 5% Significance Level
Assuming Normal Distribution	Assuming Lognormal Distribution
95% Student's t UCL 0.0777	95% H-UCL 0.0773
95% UCLs (Adjusted for Skewness)	95% Chebyshev (MVUE) UCL 0.0933
95% Adjusted CLT UCL (Chen-1995) 0.0799	97.5% Chebyshev (MVUE) UCL 0.107
95% Modified UCL (Johnson-1978) 0.0781	99% Chebyshev (MVUE) UCL 0.133
Gamma Distribution Test	Data Distribution
k star (bias corrected) 1.093	Data appear Lognormal at 5% Significance Level
Theta Chi-Square 1.093	
UCL of Mean 0.0645	
UCL of Standard Deviation 0.0617	
nu star 225.2	
Approximate Chi Square Value (US) 191.5	
Adjusted Level of Significance 0.0477	
Adjusted Chi Square Value 191	
Anderson-Darling Test Statistic 5.023	
Anderson-Darling 5% Critical Value 0.78	
Kolmogorov-Smirnov Test Statistic 0.0911	
Kolmogorov-Smirnov 5% Critical Value 0.0911	
Data not Gamma Distributed at 5% Significance Level	
Assuming Gamma Distribution	Nonparametric Statistics
Approximate Gamma UCL (Use when n >= 40) 0.0759	95% CLT UCL 0.0776
95% Adjusted Gamma UCL (Use when n < 40) 0.076	95% Jackknife UCL 0.0777
	95% Standard Bootstrap UCL 0.0774
	95% Bootstrap4 UCL 0.0815
	95% Hall's Bootstrap UCL 0.0802
	95% Percentile Bootstrap UCL 0.0788
	95% BCA Bootstrap UCL 0.08
	95% Chebyshev (Mean, Sd) UCL 0.0993
	97.5% Chebyshev (Mean, Sd) UCL 0.114
	99% Chebyshev (Mean, Sd) UCL 0.144
Potential UCL to Use	Use 95% H-UCL 0.0773
ProUCL computes and outputs H-statistic based UCLs for historical reasons only.	
H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.	
It is therefore recommended to avoid the use of H-statistic based 95% UCLs.	
Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.	
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.	
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). For additional insight, the user may want to consult a statistician.	

ProUCL 4.1 Example ISR Wellfield Ore Zone Uranium Data Set Comparison of Mean, UCL, and UTL

General Rule: Sample Mean < UCL 95% of Mean < UTL 95%-90%

1. Normal Distribution for Uranium (not indicated by GOF test):

0.0645 mg/l < 0.0777 mg/l < 0.198 mg/l

2. Lognormal Distribution for Uranium (indicated by GOF test) :

0.0388 mg/l < 0.0773 mg/l < 0.172 mg/l

3. Non Parametric – No Distribution for Uranium (recommended for skewed data sets):

0.037 (median) mg/l < 0.0993 mg/l < 0.241 mg/l

*** Question: Which is acceptable for GWPS?**

*** Answer: NRC accepts GWPS which can be technically justified**

How is restoration ground water quality data collected and analyzed?

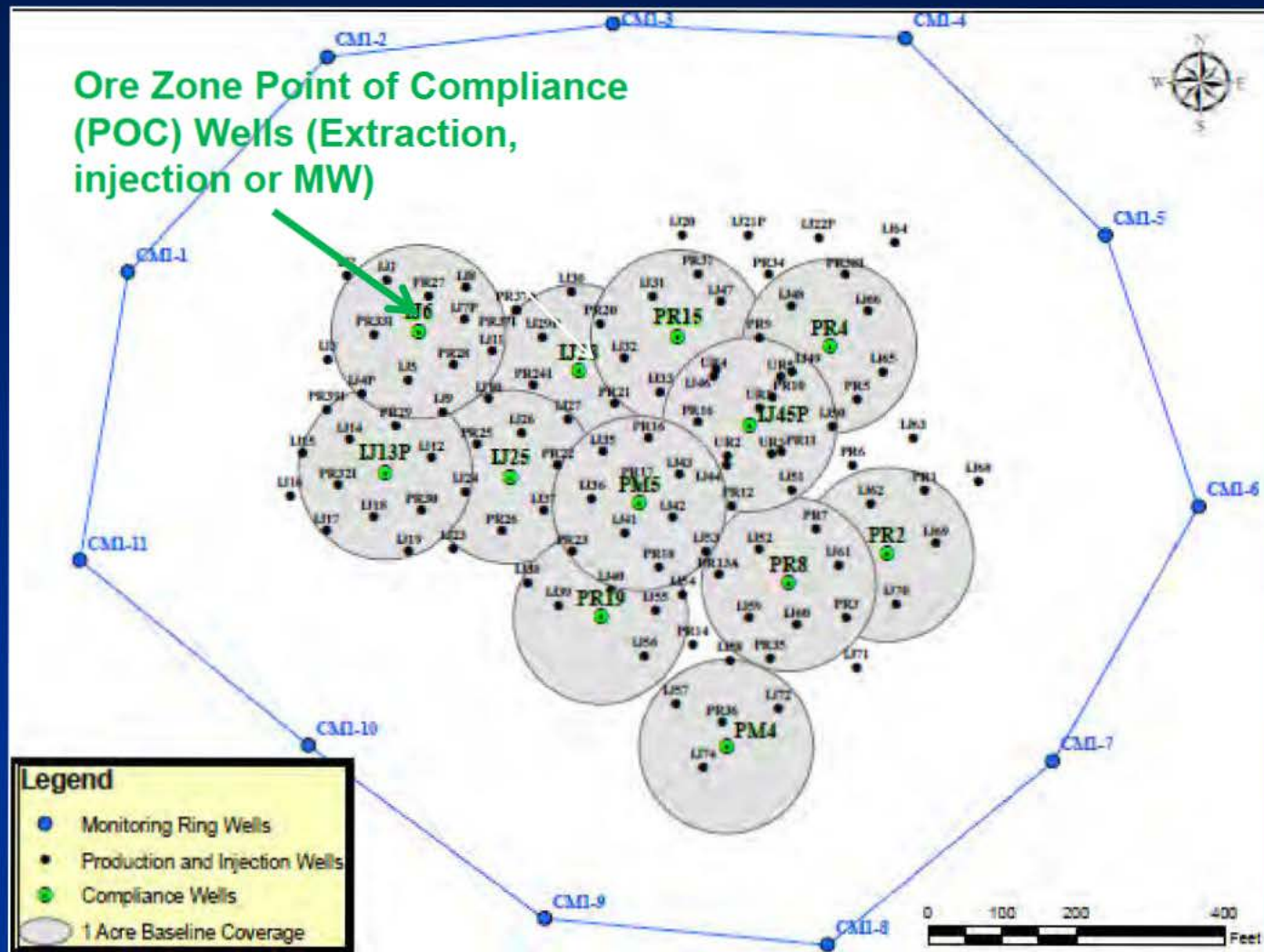
The licensee collects :

- **Restoration ground water quality of all constituents of concern (COC) at all Point of Compliance Wells (POC) for at least four quarters**

The licensee demonstrates and NRC reviews that:

- **COC meets GWPS – background GWPS previously approved.**
- **No Statistically Significant Increasing (SSI) trend for at least four consecutive quarters to demonstrate each COC GWPS will not be exceeded in POC wells after the restoration is deemed complete**

Where are the restoration water quality data collected in an ISR wellfield?



How is restoration ground water quality data reviewed?

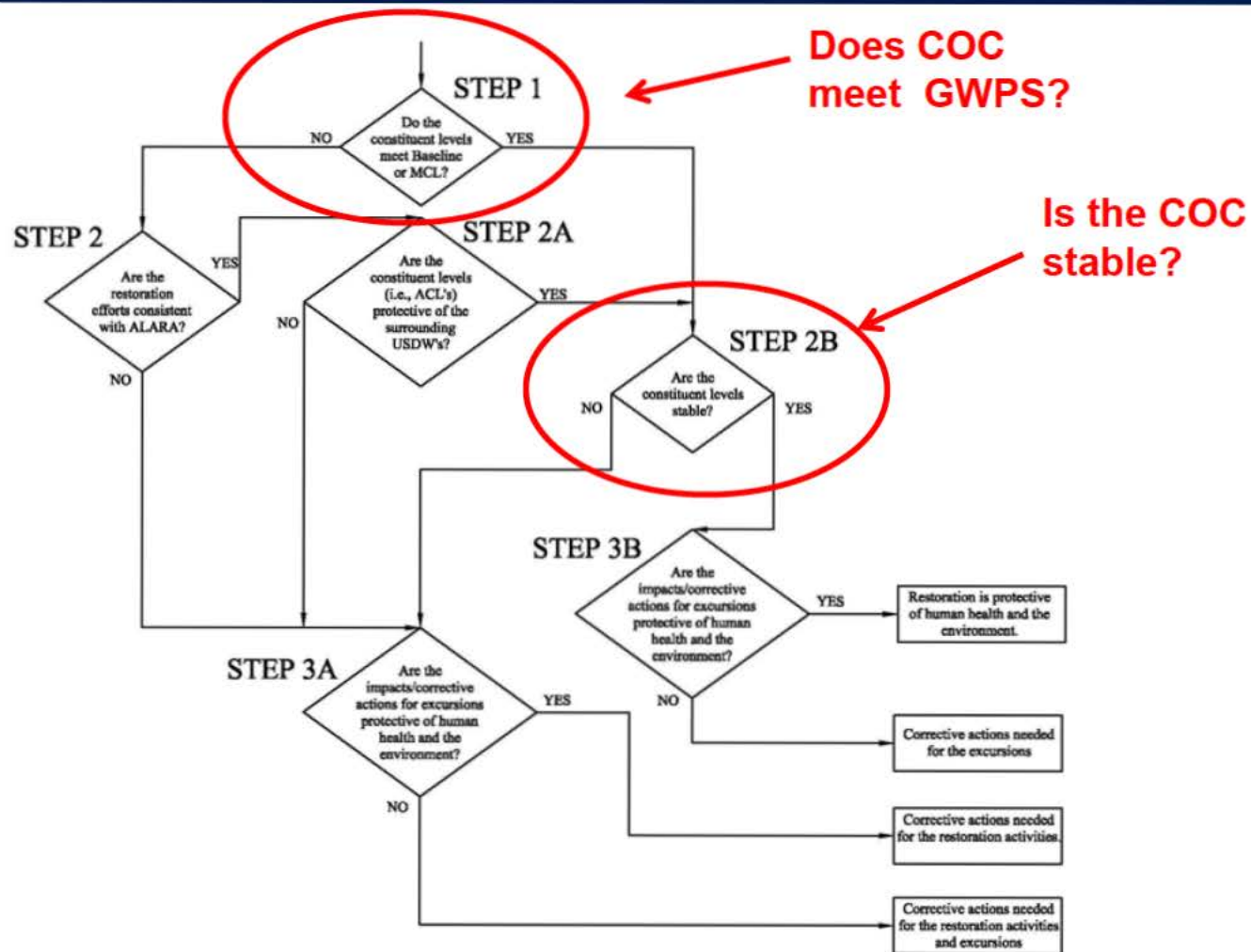
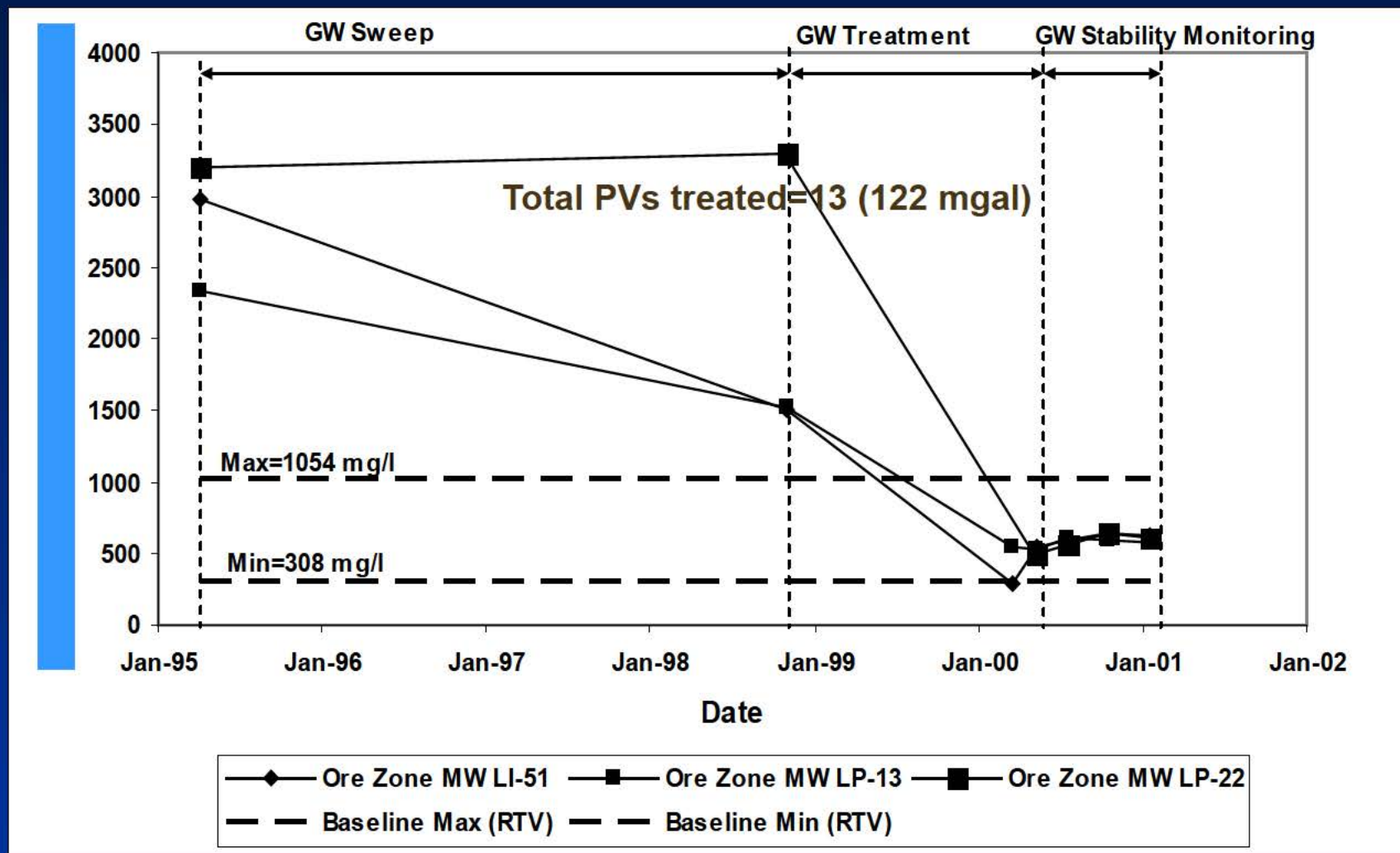


Figure 2. Flow chart depicting Staff's review process for evaluation of a restoration report.

How is restoration stability at ISR Wellfield POCs demonstrated?



Show no statistically significant increase in constituent for at least four quarters of monitoring

What are acceptable methods to determine the presence of a Statistically Significant Increase (SSI) trend in a COC?



Pro UCL 4.1 Trend Analysis

ProUCL 4.1.00

Trend Analysis: Linear Regression, Mann-Kendall
Trend Test, and Theil-Sen Trend Line

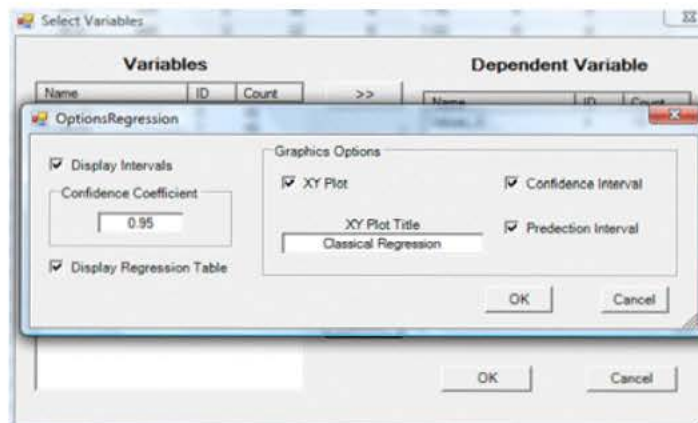
<http://www.epa.gov/osp/hstl/tsc/software.htm>

ProUCL 4.1

Trend Analysis using Linear Regression Test

Linear Regression Line

▶ Linear regression Line Test



Slope of line determines trend in data

Significant positive slope suggests upward trend

Significant negative slope suggests downward trend

Insignificant slope suggests no evidence of trend in data

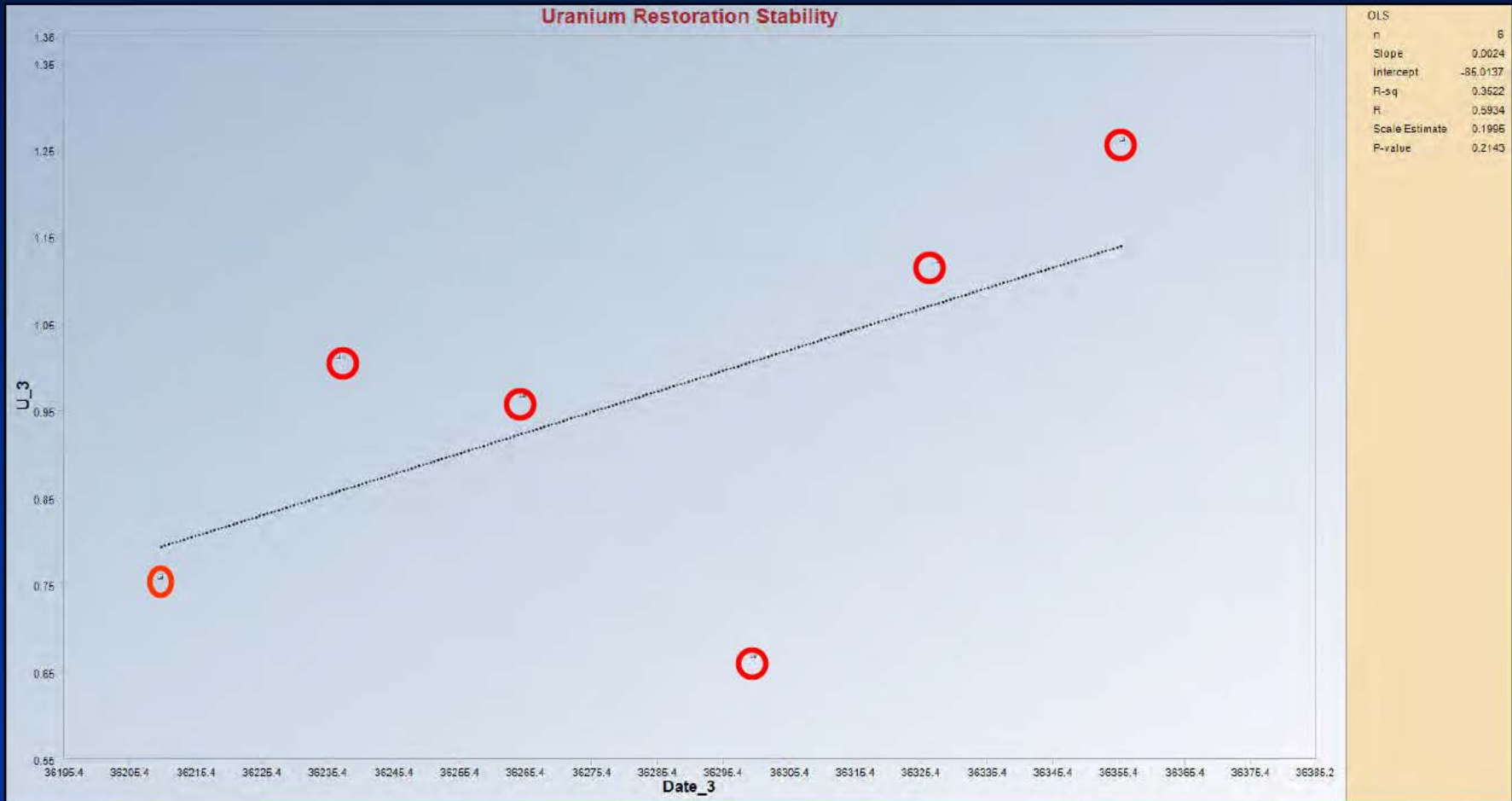
Significance is determined using p-value of slope test

ProUCL 4.1 Example

ISR Wellfield Uranium Restoration Stability

Data Trend Analysis

No Statistically Significant Increase



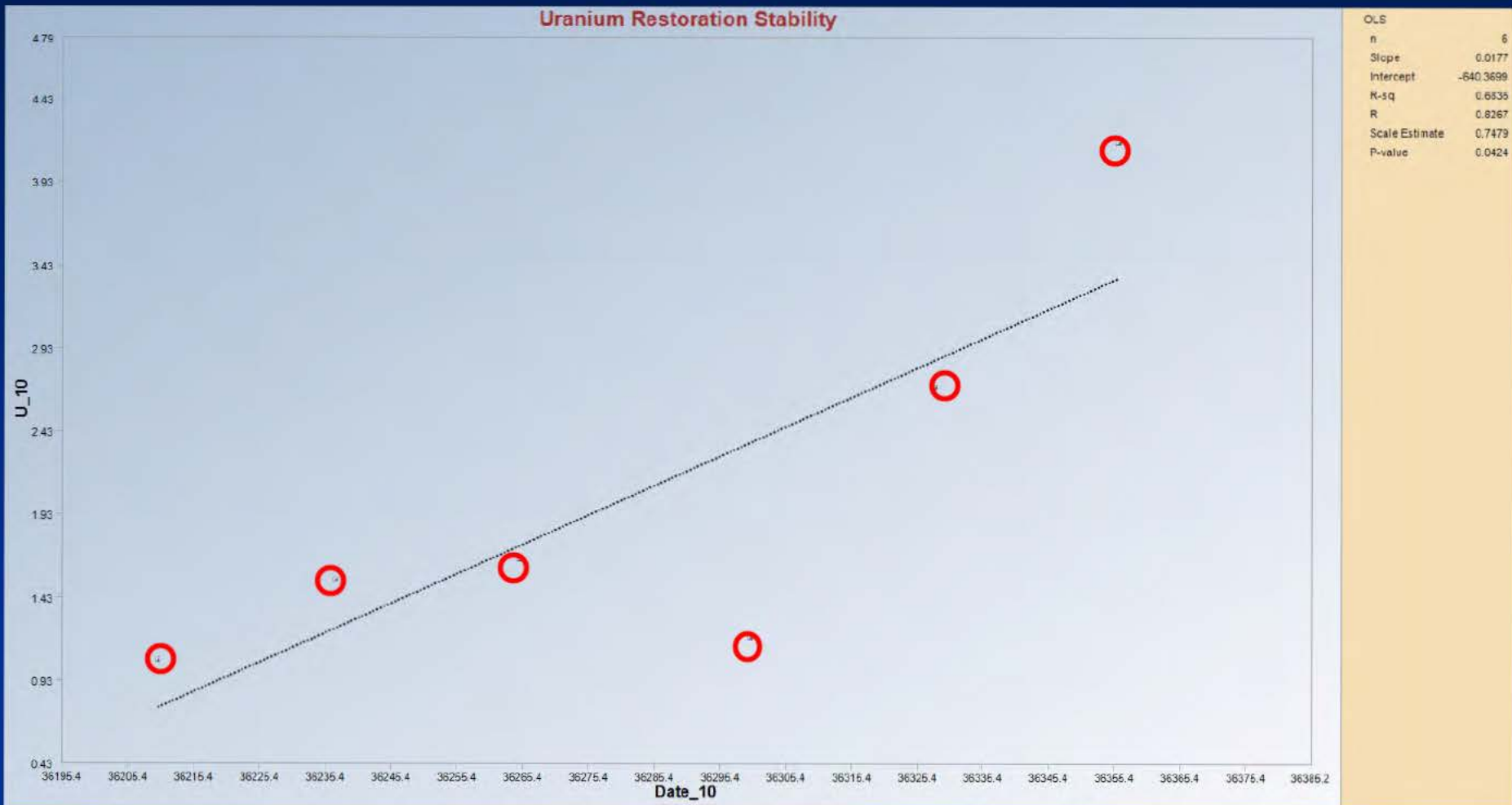
Slope is not significantly different than zero ($p=0.214$)

ProUCL 4.1 Example

ISR Wellfield Uranium Restoration Data

Stability Trend Analysis

Statistically Significant Increase



-30-

Slope is significantly different than zero ($p=0.0424$)

III. Public Access: Excel Spreadsheets for ISR Wellfield Background and Restoration Ground Water Quality

Public Access Excel Spreadsheets for ISR Wellfield Background and Restoration Ground Water Quality

Issue:

Perception by public and others that ISR wellfield ground water quality data has not been measured or is not publicly available.

Facts:

- **Large amounts of ISR wellfield ground water quality data has been provided by the licensees to NRC.**
- **This reported ISR wellfield ground water quality is publicly available in documents in ADAMs.**
- **Public and others have found access to ISR wellfield ground water quality data difficult as it must be “mined” out of ADAMs documents.**

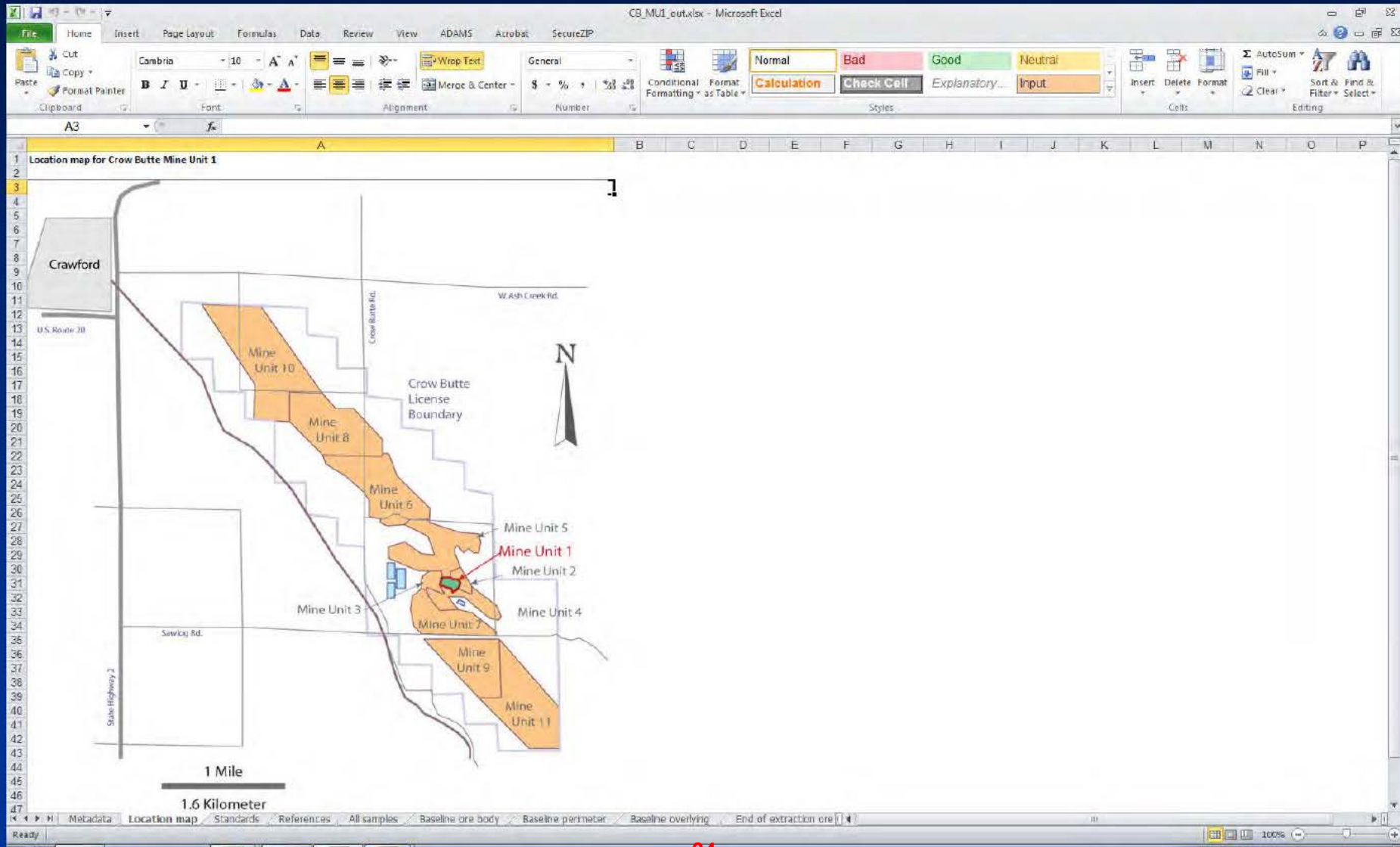
NRC Objective: Improve Public Access

- **Develop “user friendly” Excel standard format spreadsheets of publicly available ISR wellfield background and restoration water quality data from NRC licensed sites**
- **Post Excel spreadsheets to public NRC website to improve PUBLIC ACCESS to already publicly available data**



Spreadsheet Tabs for wellfield map, references, background, overlying, underlying, restoration and restoration water quality data, well completion information, etc.

Public Access Excel Spreadsheets ISR Wellfield Map



Public Access Excel Spreadsheets ISR Wellfield Restoration Stability Water Quality

CB_MU1_out.xlsx - Microsoft Excel																											
<div>FileHomeInsertPage LayoutFormulasDataReviewViewADAMSAcrobatSecureZIP</div> <div>ClipboardFontAlignmentNumberConditional FormattingStylesCellsEditing</div> <div>Caribla10A⁺⁺⁺</div>																											

Public Access Excel Spreadsheets ISR Wellfield Perimeter Monitoring Ring Well Descriptions

CB_MU1_out.xlsx - Microsoft Excel

FileHomeInsertPage LayoutFormulasDataReviewViewADAMSAcrobatSecureZIP

CutCopyFormat PainterClipboardFontAlignmentNumberConditional FormattingTableStylesCellsEditing

NormalBadGoodNeutralCalculationCheck CellExplanatory...Input

InsertDeleteFormatFillSort & FilterFind & Select

B8

1Description

2Formation(s)

3Source(s)

4Notes

5

6

7Well

8AKA

9Well type

10Easting

11ft

12Northing

13ft

14Ground surface

15elevation

16ft asl

17Top of casing

18elevation

19ft asl

20Well depth

21ft

22Casing diameter

23in

24Screen type

25Depth to top of

26screen

27ft

28Depth to bottom

29of screen

30ft

31Screen type

32Depth to top of

33screen

34ft

35Depth to bottom

36of screen

37ft

38Screen type

39Depth to top of

40screen

41ft

42Depth to bottom

43of screen

44ft

45Screen type

46Depth to top of

47screen

48ft

49Depth to bottom

50of screen

51ft

52Screen type

53Depth to top of

54screen

55ft

56Depth to bottom

57of screen

58ft

59Screen type

60Depth to top of

61screen

62ft

63Depth to bottom

64of screen

65ft

66Screen type

67Depth to top of

68screen

69ft

70Depth to bottom

71of screen

72ft

73Screen type

74Depth to top of

75screen

76ft

77Depth to bottom

78of screen

79ft

80Screen type

81Depth to top of

82screen

83ft

84Depth to bottom

85of screen

86ft

87Screen type

88Depth to top of

89screen

90ft

91Depth to bottom

92of screen

93ft

94Screen type

95Depth to top of

96screen

97ft

98Depth to bottom

99of screen

100ft

101Screen type

102Depth to top of

103screen

104ft

105Depth to bottom

106of screen

107ft

108Screen type

109Depth to top of

110screen

111ft

112Depth to bottom

113of screen

114ft

115Screen type

116Depth to top of

117screen

118ft

119Depth to bottom

120of screen

121ft

122Screen type

123Depth to top of

124screen

125ft

126Depth to bottom

127of screen

128ft

129Screen type

130Depth to top of

131screen

132ft

133Depth to bottom

134of screen

135ft

136Screen type

137Depth to top of

138screen

139ft

140Depth to bottom

141of screen

142ft

143Screen type

144Depth to top of

145screen

146ft

147Depth to bottom

148of screen

149ft

150Screen type

151Depth to top of

152screen

153ft

154Depth to bottom

155of screen

156ft

157Screen type

158Depth to top of

159screen

160ft

161Depth to bottom

162of screen

163ft

164Screen type

165Depth to top of

166screen

167ft

168Depth to bottom

169of screen

170ft

171Screen type

172Depth to top of

173screen

174ft

175Depth to bottom

176of screen

177ft

178Screen type

179Depth to top of

180screen

181ft

182Depth to bottom

183of screen

184ft

185Screen type

186Depth to top of

187screen

188ft

189Depth to bottom

190of screen

191ft

192Screen type

193Depth to top of

194screen

195ft

196Depth to bottom

197of screen

198ft

199Screen type

200Depth to top of

201screen

202ft

203Depth to bottom

204of screen

205ft

206Screen type

207Depth to top of

208screen

209ft

210Depth to bottom

211of screen

212ft

213Screen type

214Depth to top of

215screen

216ft

217Depth to bottom

218of screen

219ft

220Screen type

221Depth to top of

222screen

223ft

224Depth to bottom

225of screen

226ft

227Screen type

228Depth to top of

229screen

230ft

231Depth to bottom

232of screen

233ft

234Screen type

235Depth to top of

236screen

237ft

238Depth to bottom

239of screen

240ft

241Screen type

242Depth to top of

243screen

244ft

245Depth to bottom

246of screen

247ft

248Screen type

249Depth to top of

250screen

251ft

252Depth to bottom

253of screen

254ft

255Screen type

256Depth to top of

257screen

258ft

259Depth to bottom

260of screen

261ft

262Screen type

263Depth to top of

264screen

265ft

266Depth to bottom

267of screen

268ft

269Screen type

270Depth to top of

271screen

272ft

273Depth to bottom

274of screen

275ft

276Screen type

277Depth to top of

278screen

279ft

280Depth to bottom

281of screen

282ft

283Screen type

284Depth to top of

285screen

286ft

287Depth to bottom

288of screen

289ft

290Screen type

291Depth to top of

292screen

293ft

294Depth to bottom

295of screen

296ft

297Screen type

298Depth to top of

299screen

300ft

301Depth to bottom

302of screen

303ft

304Screen type

305Depth to top of

306screen

307ft

308Depth to bottom

309of screen

310ft

311Screen type

312Depth to top of

313screen

314ft

315Depth to bottom

316of screen

317ft

318Screen type

319Depth to top of

320screen

321ft

322Depth to bottom

323of screen

324ft

325Screen type

326Depth to top of

327screen

328ft

329Depth to bottom

330of screen

331ft

332Screen type

333Depth to top of

334screen

335ft

336Depth to bottom

337of screen

338ft

339Screen type

340Depth to top of

341screen

342ft

343Depth to bottom

344of screen

345ft

346Screen type

347Depth to top of

348screen

349ft

350Depth to bottom

351of screen

352ft

353Screen type

354Depth to top of

355screen

356ft

357Depth to bottom

358of screen

359ft

360Screen type

361Depth to top of

362screen

363ft

364Depth to bottom

365of screen

366ft

367Screen type

368Depth to top of

369screen

370ft

371Depth to bottom

372of screen

373ft

374Screen type

375Depth to top of

376screen

377ft

378Depth to bottom

379of screen

380ft

381Screen type

382Depth to top of

383screen

384ft

385Depth to bottom

386of screen

387ft

388Screen type

389Depth to top of

390screen

391ft

392Depth to bottom

393of screen

394ft

395Screen type

396Depth to top of

397screen

398ft

399Depth to bottom

400of screen

401ft

402Screen type

403Depth to top of

404screen

405ft

406Depth to bottom

407of screen

408ft

409Screen type

410Depth to top of

411screen

412ft

413Depth to bottom

414of screen

415ft

416Screen type

417Depth to top of

418screen

419ft

420Depth to bottom

421of screen

422ft

423Screen type

424Depth to top of

425screen

426ft

427Depth to bottom

428of screen

429ft

430Screen type

431Depth to top of

432screen

433ft

434Depth to bottom

435of screen

436ft

437Screen type

438Depth to top of

439screen

440ft

441Depth to bottom

442of screen

443ft

444Screen type

445Depth to top of

446screen

447ft

448Depth to bottom

449of screen

450ft

451Screen type

452Depth to top of

453screen

454ft

455Depth to bottom

456of screen

457ft

458Screen type

459Depth to top of

460screen

461ft

462Depth to bottom

463of screen

464ft

465Screen type

466Depth to top of

467screen

468ft

469Depth to bottom

470of screen

471ft

472Screen type

473Depth to top of

474screen

475ft

476Depth to bottom

477of screen

478ft

479Screen type

480Depth to top of

481screen

482ft

483Depth to bottom

484of screen

485ft

486Screen type

487Depth to top of

488screen

489ft

490Depth to bottom

491of screen

492ft

493Screen type

494Depth to top of

495screen

496ft

497Depth to bottom

498of screen

499ft

500Screen type

501Depth to top of

502screen

503ft

504Depth to bottom

505of screen

506ft

507Screen type

508Depth to top of

509screen

510ft

511Depth to bottom

512of screen

513ft

514Screen type

515Depth to top of

516screen

517ft

518Depth to bottom

519of screen

520ft

521Screen type

522Depth to top of

523screen

524ft

525Depth to bottom

526of screen

527ft

528Screen type

529Depth to top of

530screen

531ft

532Depth to bottom

533of screen

534ft

535Screen type

536Depth to top of

537screen

538ft

539Depth to bottom

540of screen

541ft

542Screen type

543Depth to top of

544screen

545ft

546Depth to bottom

547of screen

548ft

549Screen type

550Depth to top of

551screen

552ft

553Depth to bottom

554of screen

555ft

556Screen type

557Depth to top of

558screen

559ft

560Depth to bottom

561of screen

562ft

563Screen type

564Depth to top of

565screen

566ft

567Depth to bottom

568of screen

569ft

570Screen type

571Depth to top of

572screen

573ft

574Depth to bottom

575of screen

576ft

577Screen type

578Depth to top of

579screen

580ft

581Depth to bottom

582of screen

583ft

584Screen type

585Depth to top of

586screen

587ft

588Depth to bottom

589of screen

590ft

591Screen type

592Depth to top of

593screen

594ft

595Depth to bottom

596of screen

597ft

598Screen type

599Depth to top of

600screen

601ft

602Depth to bottom

603of screen

604ft

605Screen type

606Depth to top of

607screen

608ft

609Depth to bottom

610of screen

611ft

612Screen type

613Depth to top of

614screen

615ft

616Depth to bottom

617of screen

618ft

619Screen type

620Depth to top of

621screen

622ft

623Depth to bottom

624of screen

625ft

626Screen type

627Depth to top of

628screen

629ft

630Depth to bottom

631of screen

632ft

633Screen type

634Depth to top of

635screen

636ft

637Depth to bottom

638of screen

639ft

640Screen type

641Depth to top of

642screen

643ft

644Depth to bottom

645of screen

646ft

647Screen type

648Depth to top of

649screen

650ft

651Depth to bottom

652of screen

653ft

654Screen type

655Depth to top of

656screen

657ft

658Depth to bottom

659of screen

660ft

661Screen type

662Depth to top of

663screen

664ft

665Depth to bottom

666of screen

667ft

668Screen type

669Depth to top of

670screen

671ft

672Depth to bottom

673of screen

674ft

675Screen type

676Depth to top of

677screen

678ft

679Depth to bottom

680of screen

681ft

682Screen type

683Depth to top of

684screen

685ft

686Depth to bottom

687of screen

688ft

689Screen type

690Depth to top of

691screen

692ft

693Depth to bottom

694of screen

695ft

696Screen type

697Depth to top of

698screen

699ft

700Depth to bottom

701of screen

702ft

703Screen type

704Depth to top of

705screen

706ft

707Depth to bottom

708of screen

709ft

710Screen type

711Depth to top of

712screen

713ft

714Depth to bottom

715of screen

716ft

717Screen type

718Depth to top of

719screen

720ft

721Depth to bottom

722of screen

723ft

724Screen type

725Depth to top of

726screen

727ft

728Depth to bottom

729of screen

730ft

731Screen type

732Depth to top of

733screen

734ft

735Depth to bottom

736of screen

737ft

738Screen type

739Depth to top of

740screen

741ft

742Depth to bottom

743of screen

744ft

745Screen type

746Depth to top of

747screen

748ft

749Depth to bottom

750of screen

751ft

752Screen type

753Depth to top of

754screen

755ft

756Depth to bottom

757of screen

758ft

759Screen type

760Depth to top of

761screen

762ft

763Depth to bottom

764of screen

765ft

766Screen type

767Depth to top of

768screen

769ft

770Depth to bottom

771of screen

772ft

773Screen type

774Depth to top of

775screen

776ft

777Depth to bottom

778of screen

779ft

780Screen type

781Depth to top of

782screen

783ft

784Depth to bottom

785of screen

786ft

787Screen type

788Depth to top of

789screen

790ft

791Depth to bottom

792of screen

793ft

794Screen type

795Depth to top of

796screen

797ft

798Depth to bottom

799of screen

800ft

801Screen type

802Depth to top of

803screen

804ft

805Depth to bottom

806of screen

807ft

808Screen type

809Depth to top of

810screen

811ft

812Depth to bottom

813of screen

814ft

815Screen type

816Depth to top of

817screen

818ft

819Depth to bottom

820of screen

821ft

822Screen type

823Depth to top of

824screen

825ft

826Depth to bottom

827of screen

828ft

829Screen type

830Depth to top of

831screen

832ft

833Depth to bottom

834of screen

835ft

836Screen type

837Depth to top of

838screen

839ft

840Depth to bottom

841of screen

842ft

843Screen type

844Depth to top of

845screen

846ft

847Depth to bottom

848of screen

849ft

850Screen type

851Depth to top of

852screen

853ft

854Depth to bottom

855of screen

856ft

857Screen type

858Depth to top of

859screen

860ft

861Depth to bottom

862of screen

863ft

864Screen type

865Depth to top of

866screen

867ft

868Depth to bottom

869of screen

870ft

871Screen type

872Depth to top of

873screen

874ft

875Depth to bottom

876of screen

877ft

878Screen type

879Depth to top of

880screen

881ft

882Depth to bottom

883of screen

884ft

885Screen type

886Depth to top of

887screen

888ft

889Depth to bottom

890of screen

891ft

892Screen type

893Depth to top of

894screen

895ft

896Depth to bottom

897of screen

898ft

899Screen type

900Depth to top of

901screen

902ft

903Depth to bottom

904of screen

905ft

906Screen type

907Depth to top of

908screen

909ft

910Depth to bottom

911of screen

912ft

913Screen type

914Depth to top of

915screen

916ft

917Depth to bottom

918of screen

919ft

920Screen type

921Depth to top of

922screen

923ft

924Depth to bottom

925of screen

926ft

927Screen type

928Depth to top of

929screen

930ft

931Depth to bottom

932of screen

933ft

934Screen type

935Depth to top of

936screen

937ft

938Depth to bottom

939of screen

940ft

941Screen type

942Depth to top of

943screen

944ft

945Depth to bottom

946of screen

947ft

948Screen type

949Depth to top of

950screen

951ft

952Depth to bottom

953of screen

954ft

955Screen type

956Depth to top of

957screen

958ft

959Depth to bottom

960of screen

961ft

962Screen type

963Depth to top of

964screen

965ft

966Depth to bottom

967of screen

968ft

969Screen type

970Depth to top of

971screen

972ft

973Depth to bottom

974of screen

975ft

976Screen type

977Depth to top of

978screen

979ft

980Depth to bottom

981of screen

982ft

983Screen type

984Depth to top of

985screen

986ft

987Depth to bottom

988of screen

989ft

990Screen type

991Depth to top of

992screen

993ft

994Depth to bottom

995of screen

996ft

997Screen type

998Depth to top of

999screen

1000ft

1001Screen type

1002Depth to top of

1003screen

1004ft

1005Depth to bottom

1006of screen

1007ft

1008Screen type

1009Depth to top of

1010screen

1011ft

1012Depth to bottom

1013of screen

1014ft

1015Screen type

1016Depth to top of

1017screen

1018ft

1019Depth to bottom

1019of screen

1020ft

1021Screen type

1022Depth to top of

1023screen

1024ft

1025Depth to bottom

1025of screen

1026ft

1027Screen type

1028Depth to top of

1029screen

1029ft

1030Depth to bottom

1030of screen

1031ft

1032Screen type

1033Depth to top of

1034screen

1034ft

1035Depth to bottom

1035of screen

1036ft

1037Screen type

1038Depth to top of

1039screen

1039ft

1040Depth to bottom

1040of screen

1041ft

1042Screen type

1043Depth to top of

1044screen

1044ft

1045Depth to bottom

1045of screen

1046ft

1047Screen type

1048Depth to top of

1049screen

1049ft

1050Depth to bottom

1050of screen

1051ft

1052Screen type

1053Depth to top of

1054screen

1054ft

1055Depth to bottom

1055of screen

1056ft

1057Screen type

1058Depth to top of

1059screen

1059ft

1060Depth to bottom

1060of screen

1061ft

1062Screen type

1063Depth to top of

1064screen

1064ft

1065Depth to bottom

1065of screen

1066ft

1067Screen type

1068Depth to top of

1069screen

1069ft

1070Depth to bottom

1070of screen

1071ft

1072Screen type

1073Depth to top of

1074screen

1074ft

1075Depth to bottom

1075of screen

1076ft

1077Screen type

1078Depth to top of

1079screen

1079ft

1080Depth to bottom

1080of screen

1081ft

1082Screen type

1083Depth to top of

1084screen

1084ft

1085Depth to bottom

1085of screen

1086ft

1087Screen type

1088Depth to top of

1089screen

1089ft

1090Depth to bottom

1090of screen

1091ft

1092Screen type

1093Depth to top of

1094screen

1094ft

1095Depth to bottom

1095of screen

1096ft

1097Screen type

1098Depth to top of

1099screen

1099ft

1100Depth to bottom

1100of screen

1101ft

1102Screen type

1103Depth to top of

1104screen

1104ft

1105Depth to bottom

1105of screen

1106ft

1107Screen type

1108Depth to top of

1109screen

1109ft

1110Depth to bottom

1110of screen

1111ft

1112Screen type

1113Depth to top of

1114screen

1114ft

1115Depth to bottom

1115of screen

1116ft

1117Screen type

1118Depth to top of

1119screen

1119ft

1120Depth to bottom

1120of screen

1121ft

1122Screen type

1123Depth to top of

1124screen

1124ft

1125Depth to bottom

1125of screen

1126ft

1127Screen type

1128Depth to top of

1129screen

1129ft

1130Depth to bottom

1130of screen

1131ft

1132Screen type

1133Depth to top of

1134screen

1134ft

1135Depth to bottom

1135of screen

1136ft

1137Screen type

1138Depth to top of

1139screen

1139ft

1140Depth to bottom

1140of screen

1141ft

1142Screen type

1143Depth to top of

1144screen

1144ft

1145Depth to bottom

1145of screen

1146ft

1147Screen type

1148Depth to top of

1149screen

1149ft

1150Depth to bottom

1150of screen

1151ft

1152Screen type

1153Depth to top of

1154screen

1154ft

1155Depth to bottom

1155of screen

1156ft

1157Screen type

1158Depth to top of

1159screen

1159ft

1160Depth to bottom

1160of screen

Public Access Excel Spreadsheets ISR Wellfield Data References

CB_MUI_out.xlsx - Microsoft Excel

Date	Author	Title	Publisher	Location	ADAMS number
12/17/1990	Knobe, R.	Letter to D. Grams, Nebraska Department of Environmental Quality, Notice of Intent to Operate Mine Unit 1	Ferret Exploration Company of Nebraska, Inc.	Denver, CO	
01/10/2000	Crow Butte Resources, Inc.	Mine Unit 1 Restoration Report, Crow Butte Uranium Project	Crow Butte Resources, Inc.	Crawford, NE	ML003677938
10/11/2002	Crow Butte Resources, Inc.	Additional Stability Monitoring Data for Mine Unit 1 Groundwater Restoration, Crow Butte Uranium Project	Crow Butte Resources, Inc.	Crawford, NE	ML022980095

Ready

**Public Access
Excel Spreadsheets
ISR Wellfield Ground Water Quality
Status**

- **90% of publically available background and restoration ground water quality data for three NRC licensed ISR facilities has been entered into the spreadsheets**
- **Final data entry ongoing**
- **All data undergoing extensive quality assurance checks**
- **Anticipated date for posting of all spreadsheets to NRC public website - September 2013.**

Public Access Excel Spreadsheets ISR Wellfield Ground Water Quality Future Actions

Uranium Recovery Briefing to the Commission February 2013 NRC Staff Requirements Memorandum (SRM) (ML13067A365)

The staff should continue to collect groundwater monitoring well sampling data for in-situ recovery facilities. The staff should make these data publicly available and evaluate these data for insights on performance issues related to groundwater restoration and excursions events.

- 1. Background and restoration stability water quality data will continue to be added to Excel spreadsheets for existing and new licensees.**
- 2. Excursion water quality data will be added to Excel spreadsheets for all existing and new licensees.**
- 3. All ISR water quality in the spreadsheets will be posted on the NRC public web site for improved public access .**
- 4. Staff will evaluate the data for insights on performance issues with respect to meeting GWPS and protecting ground water at ISR wellfields**

Conclusions

ISR Wellfield Ground Water Quality Data Collection, Statistical Analysis and Public Access

NRC Primary Regulatory Objective: Protect the public health, safety and the environment

- **Collect adequate ISR wellfield background water quality data**
- **Use appropriate statistics (e.g. ProUCL4.1) to establish GWPS**
- **Collect adequate ISR restoration water quality data**
- **Use appropriate statistics (e.g. ProUCL4.1) to demonstrate restoration meets GWPS**
- **Use appropriate statistics (e.g. ProUCL4.1) to demonstrate restoration stability**

Public Access- ISR wellfield background, restoration and excursion ground water quality provided to NRC by licensees will be posted to NRC public website in Excel spreadsheets