

# **Effects of URI's Kingsville Dome Mine on Groundwater Quality**

**Final Report**

**Prepared for the  
Kleberg County URI Citizen Review Board**

**By  
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**July 2006**

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## 1.0 Introduction

This report was prepared for the Kleberg County URI Citizen Review Board (CRB). It presents the results of an evaluation of URI Inc.'s (URI) mining activities at its Kingsville Dome (KVD) uranium mine. The evaluation focused on groundwater quality.

The following questions are addressed:

- 1) Have mining solutions from the KVD Mine migrated beyond the boundaries of the mine (excursions)?
- 2) Have mining activities affected the quality of water in nearby domestic wells?
- 3) Has URI met the groundwater restoration requirements of the State of Texas?
- 4) Has URI complied with the Settlement Agreement between it and Kleberg County<sup>1</sup>?
- 5) Has URI restored water quality to its pre-mining condition?

## 1.1 Changes from Draft Report

A draft report was issued on April 10, 2006. This final version incorporates some changes resulting from consideration of additional information and comments provided by URI.

The major changes include:

1. A discussion of the re-mining in PAAs 1 and 2 (sections 3.1, 4.1, 7.0, and 7.2).
2. Updated restoration data. Restoration data for the first quarter of 2006 are incorporated in this report (sections 4.2, 7.2, and 7.4).
3. A recommendation that State restoration requirements apply to all production wells rather than only baseline wells (section 7.1).
4. The Conclusions and Recommendations section has been separated into two sections (sections 8 and 9).
5. A summary of URI's comments is included as appendix G.
6. Responses to URI's comments are given in appendix H.

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<sup>1</sup>Kleberg County and URI, 2004.

## 2.0 Physical Setting

The KVD Mine is in Kleberg County Texas, approximately eight miles southeast of Kingsville<sup>2</sup> (figure 2.0-1). The area licensed for mining covers approximately 2135 acres<sup>3</sup> (figure 2.0-2). Land uses in the vicinity of the mine include farming, cattle grazing and petroleum production<sup>4</sup>. The average annual rainfall is about 26 inches<sup>5</sup>.

The mine site is generally flat. The highest point is approximately 55 feet above sea level and the lowest approximately 15 feet above sea level<sup>6</sup>. Most of the site drains southward to Jaboncillos Creek<sup>7</sup>. The northern fringes drain northward toward San Fernando Creek<sup>8</sup>. Some runoff pools in shallow depressions on mine property<sup>9</sup>.

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<sup>2</sup> TBRC, 1985, page 1.

<sup>3</sup> TBRC, 1988, page 7.

<sup>4</sup> TBRC, 1988, page 10.

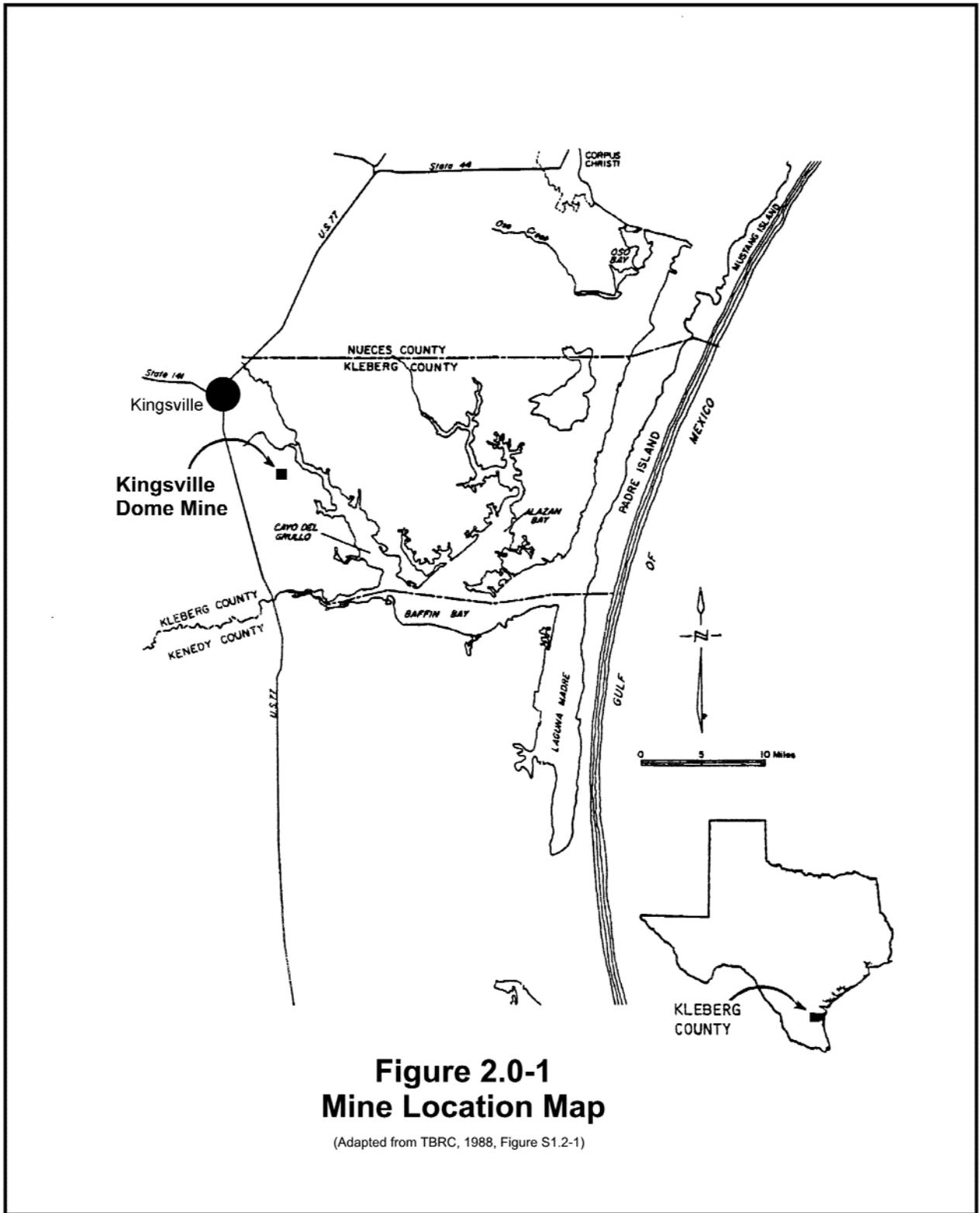
<sup>5</sup> TBRC, 1985, page 7.

<sup>6</sup> TBRC, 1988, page 11.

<sup>7</sup> TBRC, 1988, page 11.

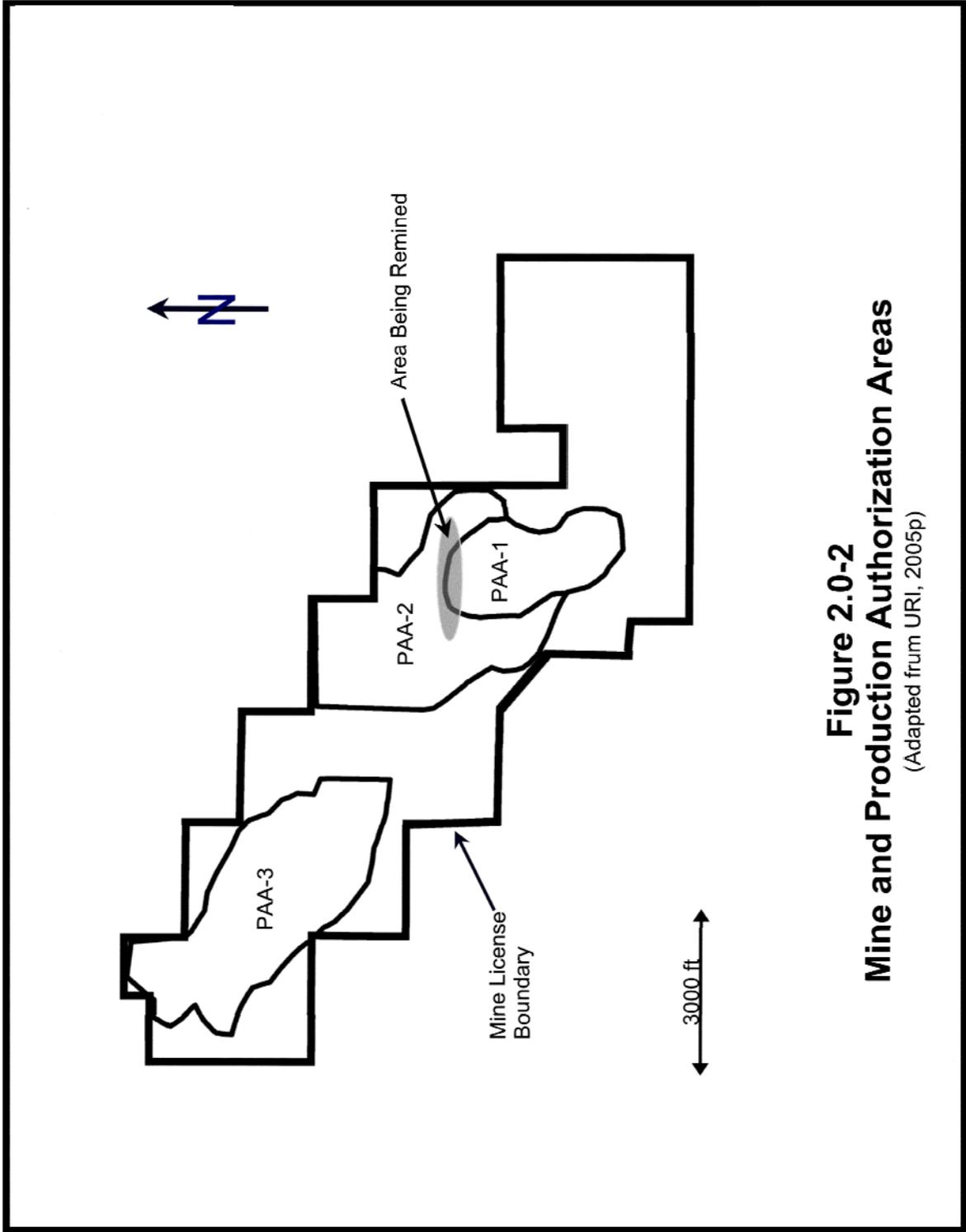
<sup>8</sup> TBRC, 1988, page 11.

<sup>9</sup> TBRC, 1988, page 14.



**Figure 2.0-1  
Mine Location Map**

(Adapted from TBRC, 1988, Figure S1.2-1)



**Figure 2.0-2**  
**Mine and Production Authorization Areas**  
(Adapted from URI, 2005p)

The site is covered by windblown silt and sand<sup>10</sup>. The windblown deposits are underlain by the Beaumont Clay-Lissie Formation, a sequence of clays and sands<sup>11</sup> (figure 2.0-3).

The uranium ore occurs in the Goliad Formation<sup>12</sup>. The Goliad consists of interbedded sandstones and clays, and is about 700 feet thick<sup>13</sup>. The top of the Goliad is about 500 feet below land surface<sup>14</sup>.

Groundwater in the Goliad Formation is confined<sup>15</sup> and generally flows toward the northwest<sup>16</sup>, although locally, groundwater flow directions may vary<sup>17</sup>. It should be noted that the current flow direction is not the natural flow direction. Under natural conditions, groundwater in the Goliad Aquifer near the KVD Mine flowed toward the coast. Pumpage in the vicinity of Kingsville has reversed the hydraulic gradient and groundwater now flows toward Kingsville<sup>18</sup>.

There are a number of domestic wells within a half mile of the mine boundary<sup>19</sup> (figure 2.0-4). These wells probably derive their water from the Goliad Formation<sup>20</sup>.

The Goliad was deposited by meandering streams<sup>21</sup>. Particle sizes range from clays to coarse sands<sup>22</sup>. Thus, the hydraulic conductivity (permeability) of this formation can be expected to vary over a wide range. The coarser channel deposits (sands) are likely to be more permeable than the finer over-bank deposits (clays).

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<sup>10</sup> TBRC, 1985, pages 24 and 25.

<sup>11</sup> TBRC, 1985, page 27.

<sup>12</sup> TBRC, 1985, page 27.

<sup>13</sup> URI, 1987a, section 3.0, *Permit Area Geology and Hydrology*.

<sup>14</sup> TBRC, 1985, pages 16 and 17.

<sup>15</sup> Static water levels in wells completed in the Goliad Formation are approximately 100 feet below land surface (URI, 2005n). They are several hundred feet above the top of the Goliad.

<sup>16</sup> TBRC, 1985, pages 53 and 60.

<sup>17</sup> URI, 1997a, PAA-3 Piezometric Map.

<sup>18</sup> TBRC, 1985, page 55.

<sup>19</sup> TBRC, 1985, page 13.

<sup>20</sup> Personal communication, Mark Pelizza of URI, October 2005.

<sup>21</sup> URI, 1987a, section 3.0, *Permit Area Geology and Hydrology*.

<sup>22</sup> Clays and sands ranging from very fine to coarse are identified in lithologic logs (e.g., A-6, AA-15, URI, 2005m).

## 2.1 Groundwater Flow Rates

Groundwater flow rates in the Goliad formation range from about 1 ft/yr to about 350 ft/yr. This range is the result of variations in hydraulic conductivity and hydraulic gradient<sup>23</sup>. The data and calculations used to derive the flow rates are presented in Appendix A.

It should be noted that the groundwater flow rate estimates given above are for non-mining conditions. That is, they are for conditions where hydraulic gradients are not affected by injection or extraction wells. Injection and extraction can result in steeper hydraulic gradients and greater groundwater flow rates.

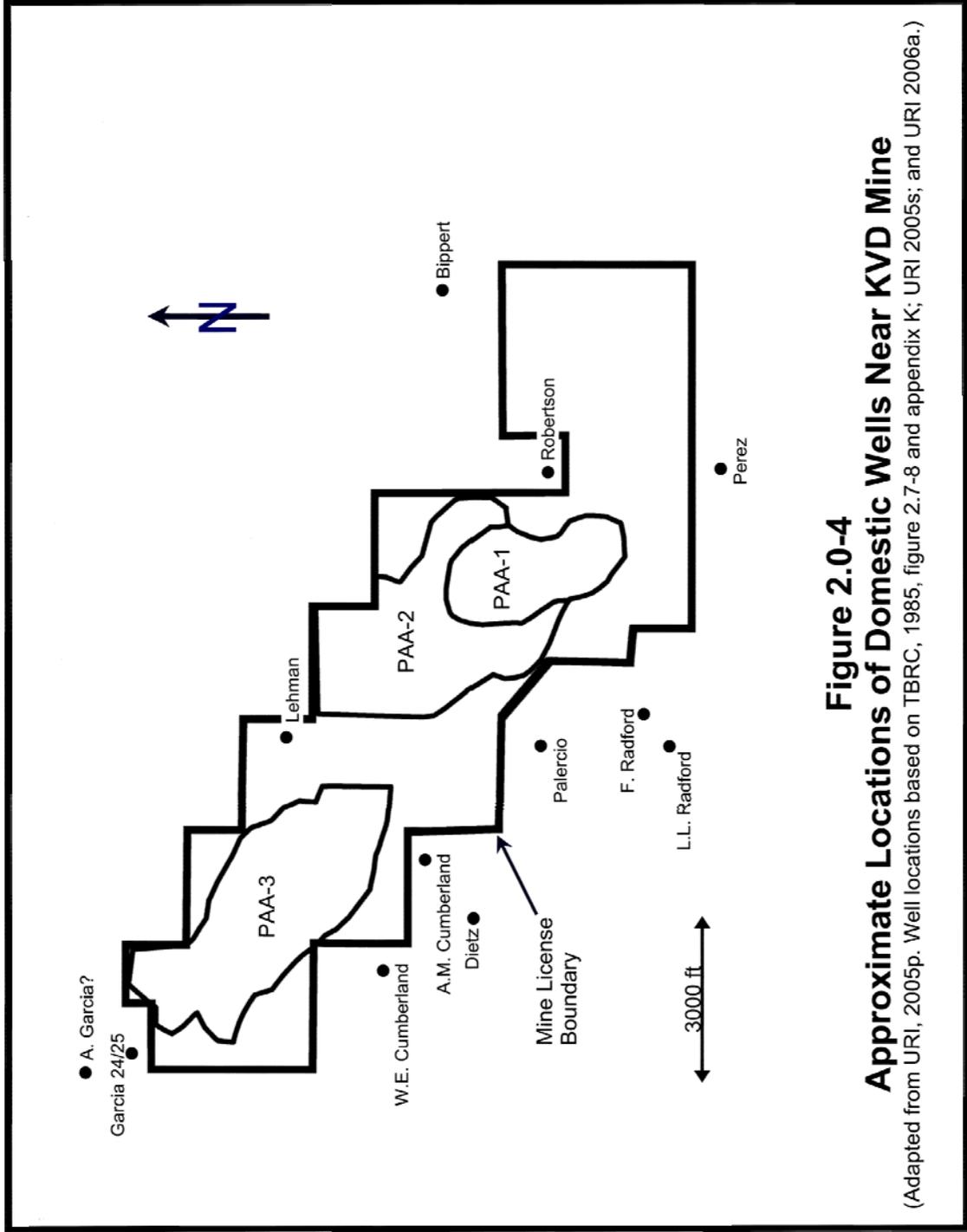
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<sup>23</sup> The hydraulic gradient is the slope of the water table or piezometric (pressure) surface. Steeper hydraulic gradients result in faster groundwater flow rates.

ERA	PERIOD	SERIES	GEOLOGIC UNIT	DESCRIPTION	
CENOZOIC	QUATERNARY	RECENT	ALLUVIUM	CALICHIFIED SAND, SILT, CLAY	
			EOLIAN DEPOSITS	CLAY-SAND DUNES, SILT SHEET, WINDBLOWN SEDIMENTS	
			BARRIER ISLAND AND BEACH DEPOSITS	SAND, SILT, CLAY	
			PLEISTOCENE	BEAUMONT CLAY AND LISSIE FORMATION (UNDIFFERENTIATED)	CALCAREOUS SAND, SILT, CLAY
	TERTIARY	PLIOCENE	GOLIAD FORMATION	FINE TO COURSE SAND, CALCAREOUS CLAY; MAIN AQUIFER AND ORE BODY	
			MIOCENE	LAGARTO CLAY	GRAY CALCAREOUS CLAY, SOME SAND
				OAKVILLE SANDSTONE	CALCAREOUS, CROSSBEDDED, COARSE SAND, SOME CLAY
		OLIGOCENE		UPPER CATAHOULA	MOSTLY TUFFS AND SAND
			CATAHOULA FORMATION	ANAHUAC FORMATION	MARINE SHALE, SOME SAND
				FRIO FORMATION	INTERBEDDED SANDS AND SHALES WITH OCCASIONAL TUFFS
				VICKSBURG (NOT EXPOSED ON SURFACE, OVERLAPPED)	GOOD MARINE SHALE, SOME SAND LENSES

**Figure 2.0-3  
General Stratigraphic Column  
For Kingsville Area**

(Adapted from TBRC, 1985, Figure 2.6-4)



**Figure 2.0-4**  
**Approximate Locations of Domestic Wells Near KVD Mine**

(Adapted from URI, 2005p. Well locations based on TBRC, 1985, figure 2.7-8 and appendix K; URI 2005s; and URI 2006a.)

### 3.0 Mining and Uranium Processing<sup>24</sup>

#### 3.1 Mining History

Mining at the KVD Mine began in 1988. The mine is divided into production areas. To date, the State of Texas has issued URI Production Authorization Area (PAA) permits for three production areas (PAAs 1, 2, and 3, figure 2.0-2). Table 3.3-1 shows the dates that uranium production began and stopped in each production area.

URI has asked the State of Texas for permission to resume mining in PAA-3.

In April 2006 URI began re-mining portions of PAAs 1 and 2<sup>25</sup>. The approximate area currently being re-mined is shown on figure 2.0-2<sup>26</sup>. URI intends to re-mine additional areas in the future<sup>27</sup>.

**Table 3.1-1**  
**Mining History for PAAs 1, 2, and 3<sup>28</sup>**

Production Area	Mining Began	Mining Stopped	Re-mining Began
PAA-1	April 1988	June 1999	April 2006
PAA-2	April 1996	June 1999	April 2006
PAA-3	June 1998	June 1999	Not Applicable

Each PAA contains production wells (injection and extraction, figure 3.2-1) and monitor wells. The production wells are installed in and near the ore bodies. Monitor wells are installed in the ore-bearing portions of the Goliad (production zone) as well as in the geologic units immediately above and below the production zone. The production zone monitor wells form a ring around the production wells. The purpose of the monitor wells is to detect excursions of mining solutions.

<sup>24</sup> The descriptions of the mining and uranium processing in this section are based on URI, 2004, pages ER-16 – ER-20; and discussions with Mike Maxson and Mark Pelizza of URI.

<sup>25</sup> URI does not call the mining it is now doing in PAAs 1 and 2 're-mining' because the uranium is being extracted from a mineral zone that was not previously mined. This zone could not be profitably mined when uranium was selling for \$15/lb, but it is profitable now that the price of uranium exceeds \$40/lb (Mark Pelizza of URI, personal communication, June 1, 2006). However, this mining is occurring in an area that was mined in the past. Therefore, the term re-mining is used in this report.

<sup>26</sup> Location of re-mining area taken from URI 2006d.

<sup>27</sup> Personal communication, Ron Grant of URI, June 2, 2006.

<sup>28</sup> Dates from URI, 2005a, responses to questions 8 and 9. The start date for PAA 3 was changed from March to June via personal communication from Mark Pelizza, December 2005. Re-mining date from Ron Grant of URI, June 2, 2006.

### 3.2 Extraction and Processing

Uranium is extracted from the production zone by in-situ leaching. Oxygen enriched water is forced into the uranium ore zones through the injection wells<sup>29</sup>. This oxidizes the uranium and releases it from the ore.

The released uranium enters the surrounding groundwater where it combines (complexes) with naturally occurring ions (e.g., carbonate, sulfate)<sup>30</sup> to form mobile uranium complexes<sup>31</sup>. The complexes remain in solution and are transported by the groundwater.

The uranium bearing groundwater (mining solution) is then pumped to the surface by extraction wells.

The mining solution is routed to resin exchange columns, which extract the uranium.

The resin columns are then flushed with a chloride-rich solution to remove the uranium. The resulting uranium-rich solution is then converted to a solid called yellowcake. Yellowcake is the end product of the KVD Mine.

The uranium processing produces brackish water that contains high concentrations of chloride and other ions. This uranium-depleted water is routed to the injection wells and reused in the uranium extraction process<sup>32</sup>.

URI extracts approximately one percent more water from the production zone than it injects. This excess pumpage (bleed) is intended to prevent the escape of mining solutions beyond the mine boundaries (excursions) by maintaining a hydraulic cone of depression around the extraction wells. The cone of depression forces the mining solution to flow toward the extraction wells.

After mining is completed in each PAA, the groundwater must be restored (see section 7).

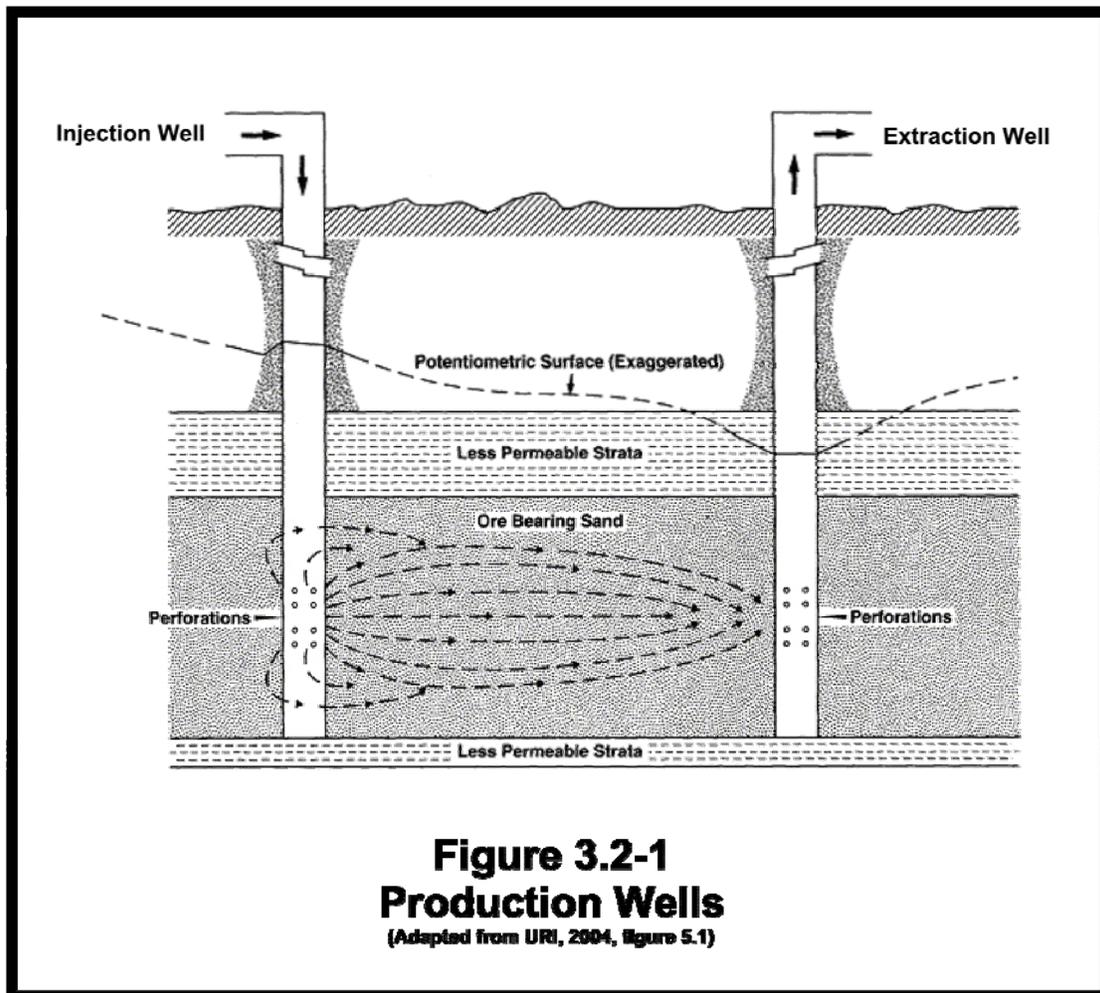
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<sup>29</sup> URI, 1999, page 6.

<sup>30</sup> Although carbonate and sulfate occur naturally in groundwater at the KVD Mine, mining causes their concentrations to increase.

<sup>31</sup> NRC, 1983, pages 10 and 31; URI, 2004, page ER-17.

<sup>32</sup> Personal communication, Mark Pelizza of URI, December 30, 2005.



## 4.0 Groundwater Quality

### 4.1 Pre-mining Quality

Pre-mining groundwater quality, or background quality, is the quality of water that existed at each PAA before any mining occurred. Background quality was determined from pre-mining samples collected from wells in each PAA.

Two types of wells were installed at each PAA before mining began; monitor wells and baseline wells. Monitor wells were installed along the perimeters of each PAA. Their purpose is to detect excursions of mining solutions. Baseline wells were installed in or near the ore bodies. Many of the baseline wells were later used as production wells. Figure 4.1-1 shows the ring of production zone monitor wells and the baseline wells at PAA-1.

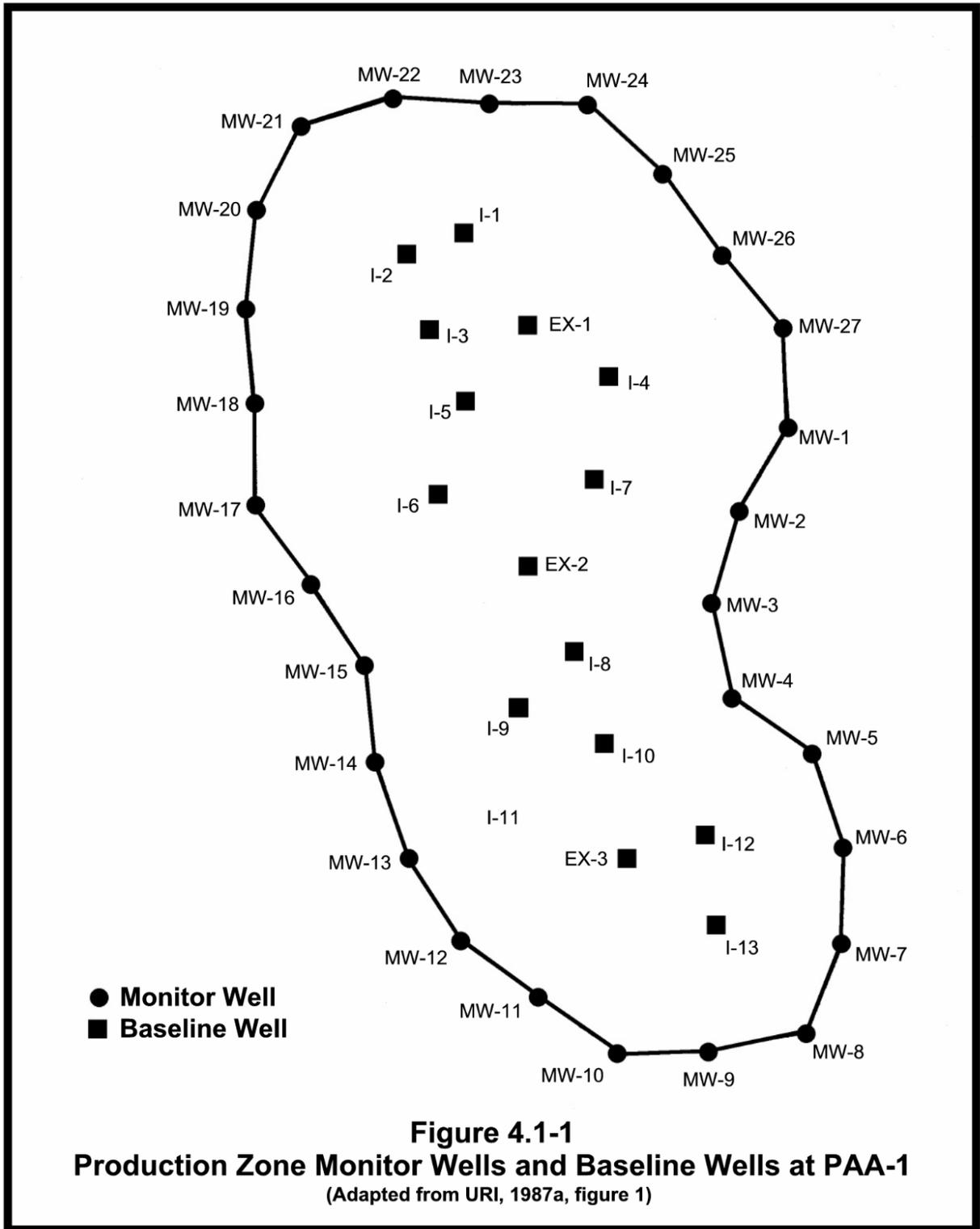
Tables 4.1-1 through 4.1-6 summarize the pre-mining water quality in monitor wells and baseline wells at each PAA<sup>33</sup>. URI has collected 'baseline' samples from wells in the area it is re-mining<sup>34</sup>. However, these wells were sampled long after mining began in PAAs 1 and 2, and are in an area that has been mined in the past. Therefore, they should not be considered pre-mining samples<sup>35</sup>.

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<sup>33</sup> A listing of baseline wells is given in table 7.1-1.

<sup>34</sup> URI 2006d.

<sup>35</sup> The question of restoration will arise (section 7.2). The restoration criteria applied to each well should be the same as the criteria for the PAA in which each well is located.



**Table 4.1-1**  
**PAA-1 Monitor Wells**  
**Pre-mining Water Quality Summary<sup>36</sup>**

Constituent	Units	Minimum	Average	Maximum
Calcium	mg/L	5.15	20.8	29.3
Magnesium	mg/L	3.81	5.0	6.07
Sodium	mg/L	311	326	346
Potassium	mg/L	4.72	6.8	8.93
Carbonate	mg/L	9	33	65
Bicarbonate	mg/L	142	268	343
Sulfate	mg/L	187	204	257
Chloride	mg/L	196	212	259
Fluoride	mg/L	0.49	0.55	0.65
Nitrate (as N)	mg/L	<0.2	0.75	2.3
Silica	mg/L	16.0	17.7	19.7
pH	SU <sup>37</sup>	8.27	8.74	9.50
TDS <sup>38</sup>	mg/L	880	954	1110
EC <sup>39</sup>	µmhos	1549	1616	1730
Alkalinity	mg/L <sup>40</sup>	219	271	306
Arsenic	mg/L	<0.01	0.004	0.02
Cadmium	mg/L	<0.01	0.01	0.03
Iron	mg/L	<0.01	0.01	0.02
Lead	mg/L	<0.01	NA <sup>41</sup>	0.01
Manganese	mg/L	<0.001	0.01	0.03
Mercury	mg/L	<0.001	<0.001	<0.001
Selenium	mg/L	<0.001	0.005	0.032
Ammonia	mg/L	0.02	0.46	6.25
Molybdenum	mg/L	<0.01	0.01	0.09
Radium 226	pCi/L	<0.18	10.64	202
Uranium	mg/L	0.002	0.057	0.34

<sup>36</sup> URI 1987a, section titled *Ground Water Analysis Reports (All Baseline and Monitor Wells)*.

<sup>37</sup> SU = standard units.

<sup>38</sup> TDS = total dissolved solids.

<sup>39</sup> EC = electrical conductivity.

<sup>40</sup> The units for alkalinity are listed as "Std. Units". It is assumed that this means mg/L as CaCO<sub>3</sub>.

<sup>41</sup> No average calculated. Majority of analytical results reported as <0.02 mg/L.

**Table 4.1-2**  
**PAA-1 Baseline Wells**  
**Pre-mining Water Quality Summary<sup>42</sup>**

Constituent	Units	Minimum	Average	Maximum
Calcium	mg/L	10.1	17.8	23.4
Magnesium	mg/L	2.8	5.1	6.2
Sodium	mg/L	316	344	349
Potassium	mg/L	5.85	7.67	12.1
Carbonate	mg/L	0	38	71
Bicarbonate	mg/L	212	255	335
Sulfate	mg/L	81	197	239
Chloride	mg/L	212	234	352
Fluoride	mg/L	0.49	0.56	0.63
Nitrate (as N)	mg/L	<0.02	0.29	1.71
Silica	mg/L	9.1	17.9	20.1
pH	SU <sup>43</sup>	7.82	8.6	8.91
TDS <sup>44</sup>	mg/L	944	997	1050
EC <sup>45</sup>	µmhos	1580	1717	2100
Alkalinity	mg/L <sup>46</sup>	205	272	338
Arsenic	mg/L	0.001	0.005	0.022
Cadmium	mg/L	<0.01	0.01	0.03
Iron	mg/L	<0.01	0.04	0.26
Lead	mg/L	<0.01	NA <sup>47</sup>	<0.02
Manganese	mg/L	<0.001	0.01	0.03
Mercury	mg/L	<0.0002	NA <sup>48</sup>	0.01
Selenium	mg/L	<0.001	0.007	0.072
Ammonia	mg/L	<0.01	1.06	13.0
Molybdenum	mg/L	<0.01	0.06	0.20
Radium 226	pCi/L	0.66	21.63	47.6
Uranium	mg/L	0.008	0.159	0.927

<sup>42</sup> URI 1987a, section titled *Ground Water Analysis Reports (All Baseline and Monitor Wells)*.

<sup>43</sup> SU = standard units.

<sup>44</sup> TDS = total dissolved solids.

<sup>45</sup> EC = electrical conductivity.

<sup>46</sup> The units for alkalinity are listed as "Std. Units". It is assumed that this means mg/L as CaCO<sub>3</sub>.

<sup>47</sup> No average calculated. Majority of analytical results reported as <0.02 mg/L.

<sup>48</sup> No average calculated. Majority of analytical results reported as <0.001 mg/L.

**Table 4.1-3  
PAA-2 Monitor Wells  
Pre-mining Water Quality Summary<sup>49</sup>**

<b>Constituent</b>	<b>Units</b>	<b>Minimum</b>	<b>Average</b>	<b>Maximum</b>
Calcium	mg/L	8.4	25.3	74
Magnesium	mg/L	3.3	5.5	10
Sodium	mg/L	296	318	352
Potassium	mg/L	5.1	6.7	9
Carbonate	mg/L	0	7	23
Bicarbonate	mg/L	253	327	505
Sulfate	mg/L	13	183	227
Chloride	mg/L	198	231	336
Fluoride	mg/L	0.55	0.65	1.10
Nitrate (as N)	mg/L	0.01	0.89	5.8
Silica	mg/L	18	22	30
pH	SU <sup>50</sup>	7.37	8.33	8.94
TDS <sup>51</sup>	mg/L	914	1008	1230
EC <sup>52</sup>	µmhos	1490	1648	2020
Alkalinity	mg/L <sup>53</sup>	240	280	444
Arsenic	mg/L	<0.001	0.004	0.023
Cadmium	mg/L	<0.0001	0.0002	0.0017
Iron	mg/L	0.01	0.03	0.16
Lead	mg/L	<0.001	0.002	0.014
Manganese	mg/L	<0.01	0.02	0.08
Mercury	mg/L	<0.0001	<0.0001	<0.0001
Selenium	mg/L	<0.001	0.002	0.006
Ammonia	mg/L	0.01	0.08	0.2
Molybdenum	mg/L	<0.01	0.03	0.2
Radium 226	pCi/L	0.4	3.3 <sup>54</sup>	8.2
Uranium	mg/L	<0.001	0.019	0.272

<sup>49</sup> URI 1989a, section titled *Ground Water Analysis Reports (All Baseline and Monitor Wells)*.

<sup>50</sup> SU = standard units.

<sup>51</sup> TDS = total dissolved solids.

<sup>52</sup> EC = electrical conductivity.

<sup>53</sup> The units for alkalinity are listed as "Std. Units". It is assumed that this means mg/L as CaCO<sub>3</sub>.

<sup>54</sup> Radium analyzed for only 13 of 40 pre-mining monitor well samples.

**Table 4.1-4  
PAA-2 Baseline Wells  
Pre-mining Water Quality Summary<sup>55</sup>**

<b>Constituent</b>	<b>Units</b>	<b>Minimum</b>	<b>Average</b>	<b>Maximum</b>
Calcium	mg/L	12	22	35
Magnesium	mg/L	3.9	5.1	6.2
Sodium	mg/L	315	323	338
Potassium	mg/L	6.3	8.2	9.6
Carbonate	mg/L	0	4	16
Bicarbonate	mg/L	246	297	333
Sulfate	mg/L	206	224	239
Chloride	mg/L	209	224	239
Fluoride	mg/L	0.57	0.61	0.65
Nitrate (as N)	mg/L	0.09	0.50	1.2
Silica	mg/L	22	27	34
pH	SU <sup>56</sup>	8.15	8.34	8.66
TDS <sup>57</sup>	mg/L	976	1035	1070
EC <sup>58</sup>	µmhos	1590	1662	1720
Alkalinity	mg/L <sup>59</sup>	228	250	273
Arsenic	mg/L	<0.001	0.006	0.017
Cadmium	mg/L	<0.0001	0.0001	0.0001
Iron	mg/L	0.02	0.02	0.03
Lead	mg/L	<0.001	0.004	0.017
Manganese	mg/L	<0.01	0.01	0.01
Mercury	mg/L	<0.0001	0.0001	0.0001
Selenium	mg/L	0.001	0.008	0.017
Ammonia	mg/L	0.08	0.15	0.23
Molybdenum	mg/L	0.05	0.38	0.84
Radium 226	pCi/L	31	92	157
Uranium	mg/L	0.252	1.89	3.75

<sup>55</sup> URI 1989a, section titled *Ground Water Analysis Reports (All Baseline and Monitor Wells)*.

<sup>56</sup> SU = standard units.

<sup>57</sup> TDS = total dissolved solids.

<sup>58</sup> EC = electrical conductivity.

<sup>59</sup> The units for alkalinity are listed as "Std. Units". It is assumed that this means mg/L as CaCO<sub>3</sub>.

**Table 4.1-5  
PAA-3 Monitor Wells  
Pre-mining Water Quality Summary<sup>60</sup>**

<b>Constituent</b>	<b>Units</b>	<b>Minimum</b>	<b>Average</b>	<b>Maximum</b>
Calcium	mg/L	10	17	34
Magnesium	mg/L	1.5	6.9	16.0
Sodium	mg/L	332	404	525
Potassium	mg/L	8.1	10.4	16.0
Carbonate	mg/L	0	0.4	5
Bicarbonate	mg/L	113	232	298
Sulfate	mg/L	199	351	557
Chloride	mg/L	214	282	443
Fluoride	mg/L	0.00	0.89	3.80
Nitrate (as N)	mg/L	0.47	0.59	0.77
Silica	mg/L	15	19	22
pH	SU <sup>61</sup>	7.30	8.09	8.44
TDS <sup>62</sup>	mg/L	917	1221	1570
EC <sup>63</sup>	µmhos	1600	2017	2590
Alkalinity	mg/L <sup>64</sup>	93	191	244
Arsenic	mg/L	<0.0001	0.006	0.029
Cadmium	mg/L	<0.0001	<0.0001	<0.0001
Iron	mg/L	<0.01	0.02	0.13
Lead	mg/L	<0.0001	0.003	0.034
Manganese	mg/L	<0.01	0.01	0.07
Mercury	mg/L	<0.0001	<0.0001	<0.0001
Selenium	mg/L	<0.001	0.009	0.049
Ammonia	mg/L	<0.01	0.04	0.27
Molybdenum	mg/L	<0.01	0.23	3.50
Radium 226	pCi/L	0.01	4.5	72.0
Uranium	mg/L	<0.001	0.041	0.187

<sup>60</sup> URI 1997a, section titled *Ground Water Analysis Reports*.

<sup>61</sup> SU = standard units.

<sup>62</sup> TDS = total dissolved solids.

<sup>63</sup> EC = electrical conductivity.

<sup>64</sup> The units for alkalinity are listed as "Std. Units". It is assumed that this means mg/L as CaCO<sub>3</sub>.

**Table 4.1-6**  
**PAA-3 Baseline Wells <sup>65</sup>**  
**Pre-mining Water Quality Summary<sup>66</sup>**

Constituent	Units	Minimum	Average	Maximum
Calcium	mg/L	10	16	25
Magnesium	mg/L	1.5	3.8	6.0
Sodium	mg/L	203	387	480
Potassium	mg/L	7.7	16.1	31.0
Carbonate	mg/L	0	16	49
Bicarbonate	mg/L	95	165	321
Sulfate	mg/L	183	349	487
Chloride	mg/L	138	275	362
Fluoride	mg/L	0.00	0.19	2.10
Nitrate (as N)	mg/L	0.49	0.67	0.97
Silica	mg/L	17	20	23
pH	SU <sup>67</sup>	7.69	8.70	9.6
TDS <sup>68</sup>	mg/L	667	1143	1440
EC <sup>69</sup>	µmhos	1120	1825	2820
Alkalinity	mg/L <sup>70</sup>	78	162	263
Arsenic	mg/L	0.003	0.009	0.025
Cadmium	mg/L	<0.0001	NA <sup>71</sup>	0.0001
Iron	mg/L	<0.01	0.01	0.04
Lead	mg/L	<0.001	NA <sup>72</sup>	0.001
Manganese	mg/L	<0.01	NA <sup>73</sup>	0.01
Mercury	mg/L	<0.0001	<0.0001	<0.0001
Selenium	mg/L	<0.001	0.014	0.063
Ammonia	mg/L	<0.01	0.18	0.40
Molybdenum	mg/L	0.02	0.30	3.20
Radium 226	pCi/L	0.3	23.3	78
Uranium	mg/L	0.032	0.351	1.54

<sup>65</sup> Baseline wells BL-8501 – BL-8511 were analyzed for all constituents in the table. Baseline wells 9101, 9103, 9105, 9107, 9109, 9111, 9113, 9302, 9304, 9306, 9308, 9310, 9312, 9314, 9315, 9602, were analyzed only for pH, EC, molybdenum, radium 226, and uranium. Baseline wells 9308 and 9310 were sampled twice. The average of the two sample analyses was used to calculate the averages in the table.

<sup>66</sup> URI 1997a, section titled *Ground Water Analysis Reports*.

<sup>67</sup> SU = standard units.

<sup>68</sup> TDS = total dissolved solids.

<sup>69</sup> EC = electrical conductivity.

<sup>70</sup> The units for alkalinity are listed as “Std. Units”. It is assumed that this means mg/L as CaCO<sub>3</sub>.

<sup>71</sup> No average calculated. Majority of analytical results reported as <0.0001 mg/L.

<sup>72</sup> No average calculated. Majority of analytical results reported as <0.001 mg/L.

<sup>73</sup> No average calculated. Majority of analytical results reported as <0.01 mg/L.

In general, pre-mining groundwater quality was poor in both monitor wells and baseline wells. Except for the monitor wells at PAA-2, average concentrations of uranium exceeded the EPA primary drinking water standards<sup>74</sup> in all PAAs. Average concentrations of total dissolved solids (TDS) exceeded the EPA secondary drinking water standard<sup>75</sup> in all PAAs. Table 4.1-7 shows the number of wells in each PAA that met the standards for uranium or TDS.

**Table 4.1-7  
Pre-Mining Water Quality  
Number of Wells Meeting EPA Uranium or TDS Standards<sup>76</sup>**

<b>PAA</b>	<b>Well Type</b>	<b>Uranium Concentrations Less than EPA Standard (0.03 mg/L)</b>	<b>Uranium Concentrations More than EPA Standard (0.03 mg/L)</b>	<b>TDS Concentrations Less than EPA Standard (500 mg/L)</b>	<b>TDS Concentrations More than EPA Standard (500 mg/L)</b>
<b>1</b>	Monitor	13	14	0	27
	Baseline	5	11	0	16
<b>2</b>	Monitor	38	3	0	41
	Baseline	0	5	0	5
<b>3</b>	Monitor	20	29	0	49
	Baseline	0	11	0	11

Other constituents that exceeded EPA primary drinking water standards in at least one well before mining began are arsenic, cadmium, lead, mercury, selenium, and radium-226<sup>77</sup>. Other constituents that exceeded EPA secondary drinking water standards in at least one well before mining began are chloride, fluoride, manganese, pH, and sulfate<sup>78</sup>.

<sup>74</sup> An EPA primary standard is a legally enforceable standard that applies to public water systems. Primary standards protect drinking water quality by limiting the levels of specific contaminants that can adversely affect public health. They take the form of Maximum Contaminant Levels or Treatment Techniques (EPA, 2005).

<sup>75</sup> An EPA secondary standard is a non-enforceable guideline for contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. States, however, may choose to adopt them as enforceable standards. (EPA, 2005).

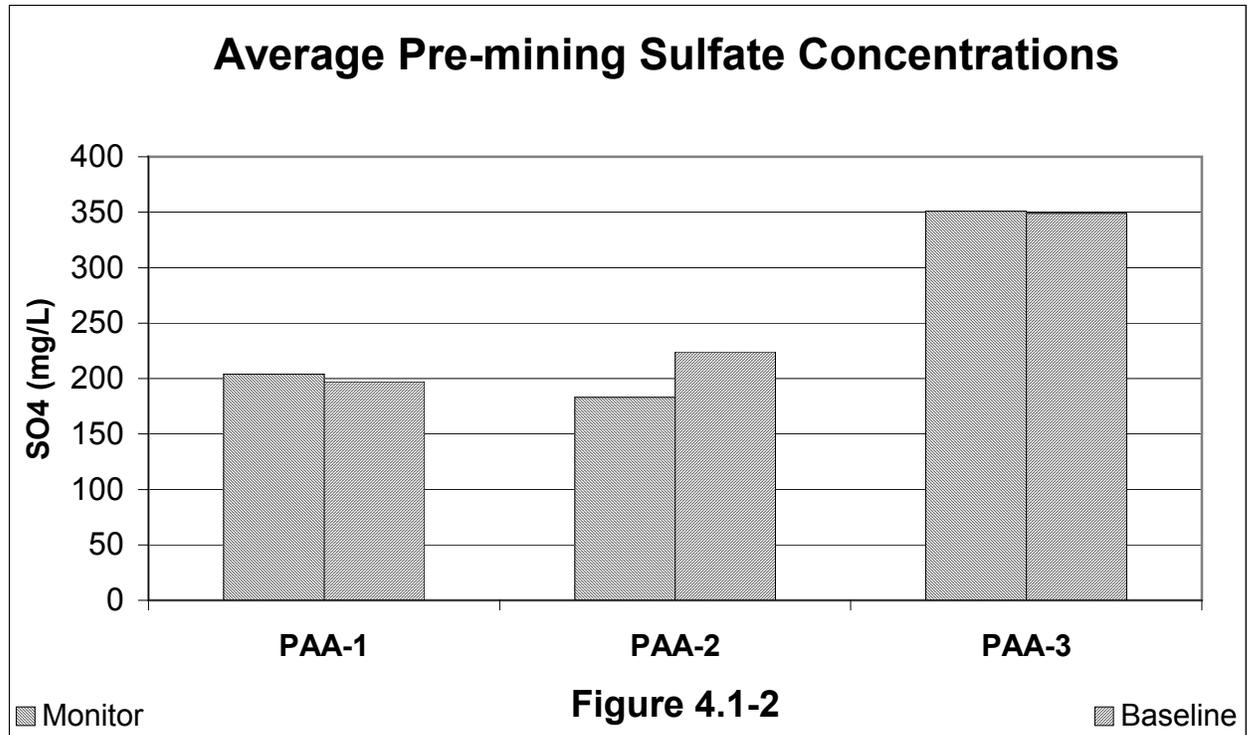
<sup>76</sup> Data from URI 1987a, URI 1989a, and URI 1997a. EPA standards from EPA, 2004.

<sup>77</sup> EPA primary drinking water standards: arsenic (0.01 mg/L), cadmium (0.005 mg/L), lead (0.015 mg/L action level), mercury (0.002 mg/L), selenium (0.05 mg/L), and radium-226 (5 pCi/L) (EPA, 2004).

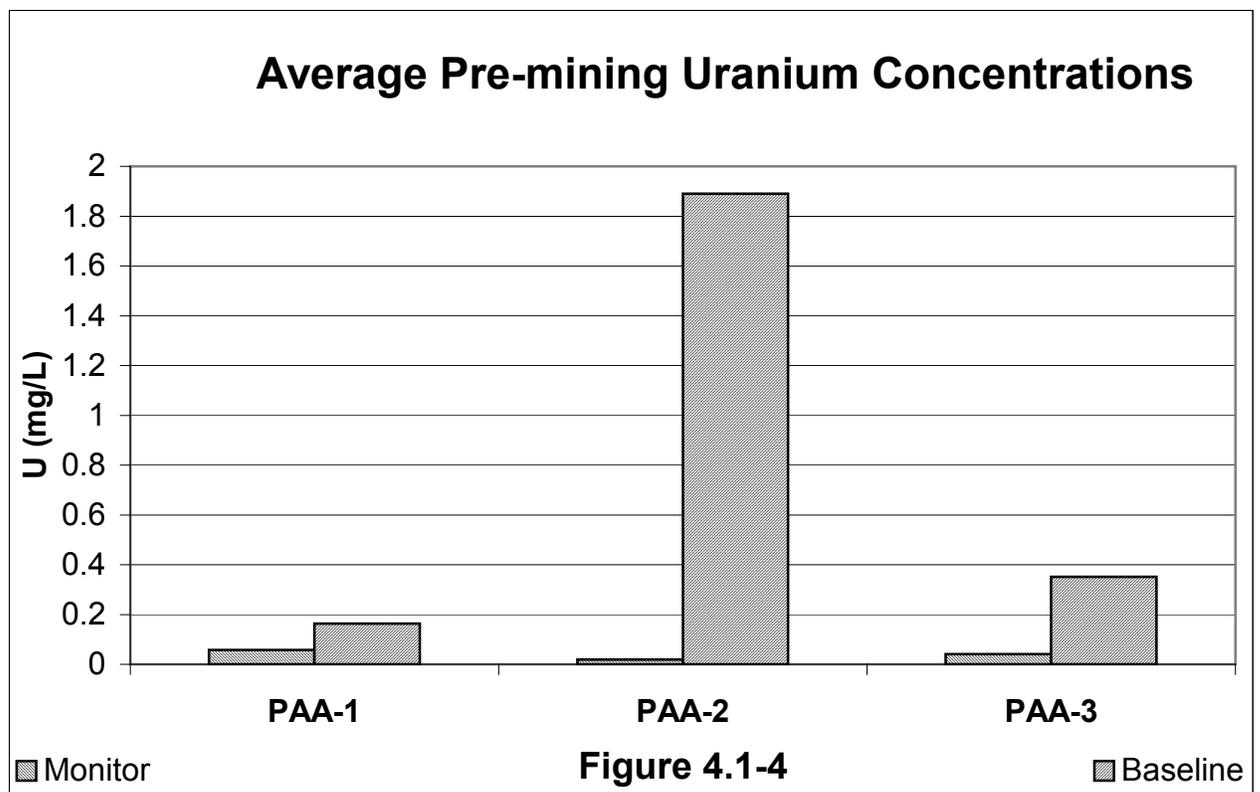
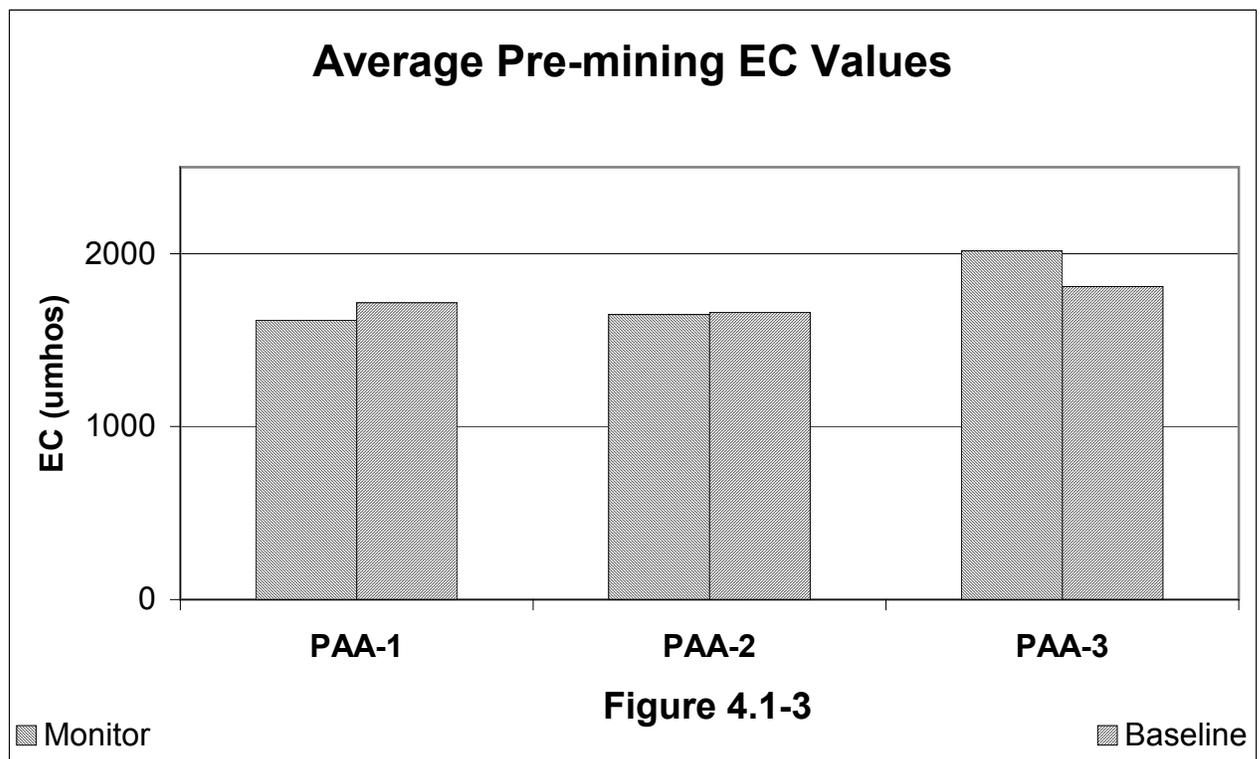
<sup>78</sup> EPA secondary drinking water standards: chloride (250 mg/L), fluoride (2.0 mg/L, note: primary standard for fluoride is 4.0 mg/L), manganese (0.05 mg/L), pH (6.5 – 8.5), and sulfate (250 mg/L) (EPA, 2004).

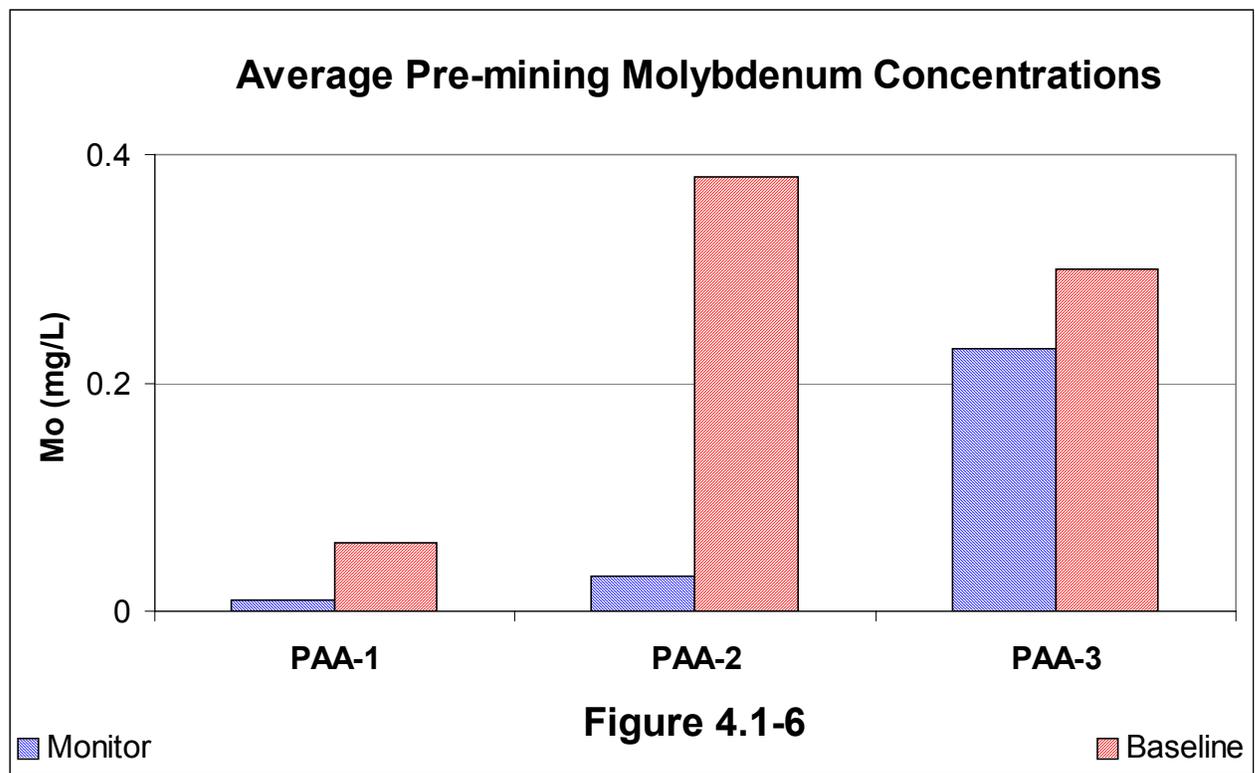
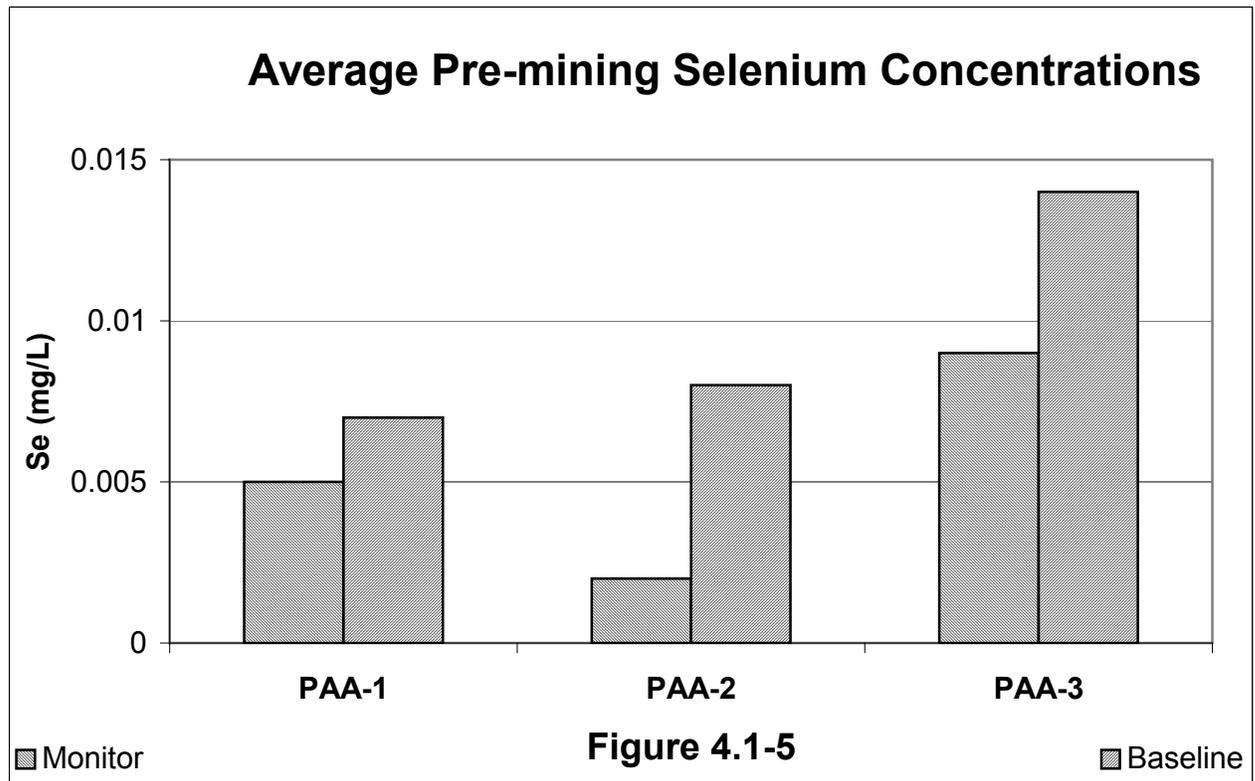
For most constituents, the pre-mining quality of water from monitor wells was similar to the quality of water from baseline wells. Figures 4.1-2 and 4.1-3 compare the average pre-mining levels of sulfate and electrical conductivity (EC)<sup>79</sup> in monitor wells and baseline wells at each PAA.

There were differences, however, between some of the constituents associated with uranium ore. Average concentrations of ore-associated constituents such as uranium, selenium, and molybdenum were lower in monitor wells than in baseline wells (figures 4.1-4 through 4.1-6).



<sup>79</sup> EC is similar to TDS in that it is a gross determination of the total concentration all dissolved constituents in a solution. EC is a measure of the ability of a solution to transmit an electrical current. In general, the EC of a solution increases as the concentrations of dissolved constituents increase.





## 4.2 Post-mining Quality

The injection of oxygen mobilizes constituents in the ore bodies, resulting in the deterioration of water quality. Table 4.2-1 shows typical concentrations of constituents in the mining solution (pregnant lixiviant) during production.

**Table 4.2-1  
Typical Concentrations of Constituents in Mining Solution<sup>80</sup>**

pH (SU)	EC (µmhos/cm)	Uranium (mg/L)	Chloride (mg/L)	Calcium (mg/L)	Bicarbonate (mg/L)	Sulfate (mg/L)	Molybdenum (mg/L)
6.6	4000	80	600	400	800	1200	10

The detrimental effects of mining on water quality can be seen by comparing the concentrations of constituents in the mining solution (table 4.2-1) with concentrations in pre-mining groundwater (tables 4.1-1 through 4.1-6). Constituent concentrations are much higher during mining.

Water quality has improved since mining operations stopped in 1999. However, the average concentrations of some constituents still remain higher than pre-mining concentrations. These include sulfate, molybdenum, and uranium. Figures 4.2-1 through 4.2-3 compare the average pre-mining and post-mining concentrations in baseline wells at PAAs 1 and 2<sup>81</sup>.

It should be noted that some of the uranium analyses performed by URI might not be reliable. This issue is discussed in appendices B and H, response to comment 3.

Since mining began, high concentrations of radon-222 have been found in production wells at the KVD Mine<sup>82</sup>. Radon-222 concentrations ranged from 17,800 pCi/L to 314,00 pCi/L<sup>83</sup>. The EPA has proposed a primary drinking water standard for radon-222 of 300 pCi/L<sup>84</sup>. Unfortunately, no pre-mining radon samples were collected at the mine.

<sup>80</sup> URI analysis of pregnant lixiviant. Pregnant lixiviant is the mining solution that is pumped from the extraction wells to the plant for processing. It may be a mixture of mining solutions from many extraction wells. Data from Mark Pelizza of URI, December 2005.

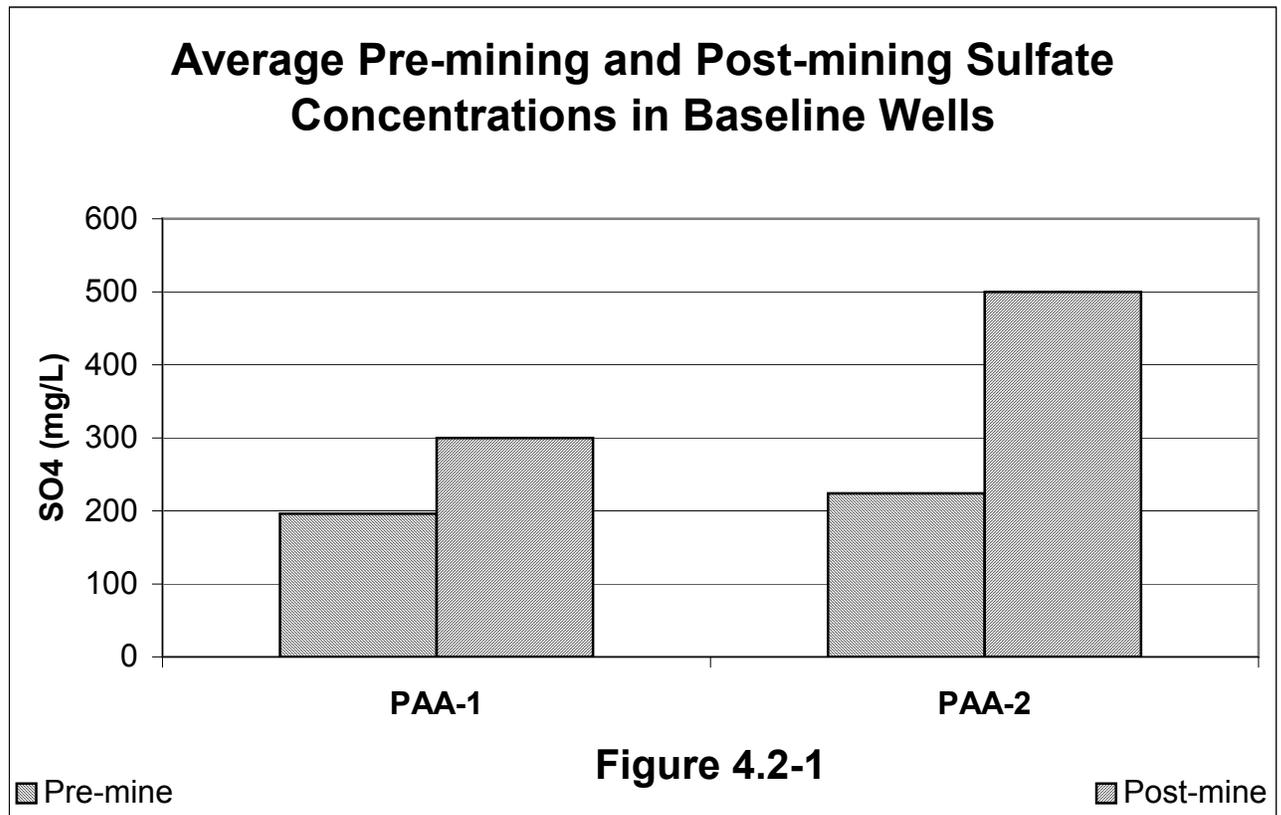
<sup>81</sup> Post-mining concentrations were taken from the latest restoration progress report (URI, 2006e). In cases where a constituent was not detected, the average was calculated using one half the detection limit. Uranium values were converted from U<sub>3</sub>O<sub>8</sub> by multiplying by 0.848. Data for PAA-3 are not presented because restoration has not begun at PAA-3 and URI is not collecting samples from the PAA-3 baseline wells.

<sup>82</sup> URI, 2006a. These particular production wells are neither monitor wells nor baseline wells. URI refers to these wells as 'supplemental baseline wells' (see section 7.1.1).

<sup>83</sup> URI, 1987a; URI 1989a.

<sup>84</sup> EPA, 2004.

The issue of radon-222 is also discussed in appendix H, responses to comments 1 and 12.



### Average Pre-mining and Post-mining Molybdenum Concentrations in Baseline Wells

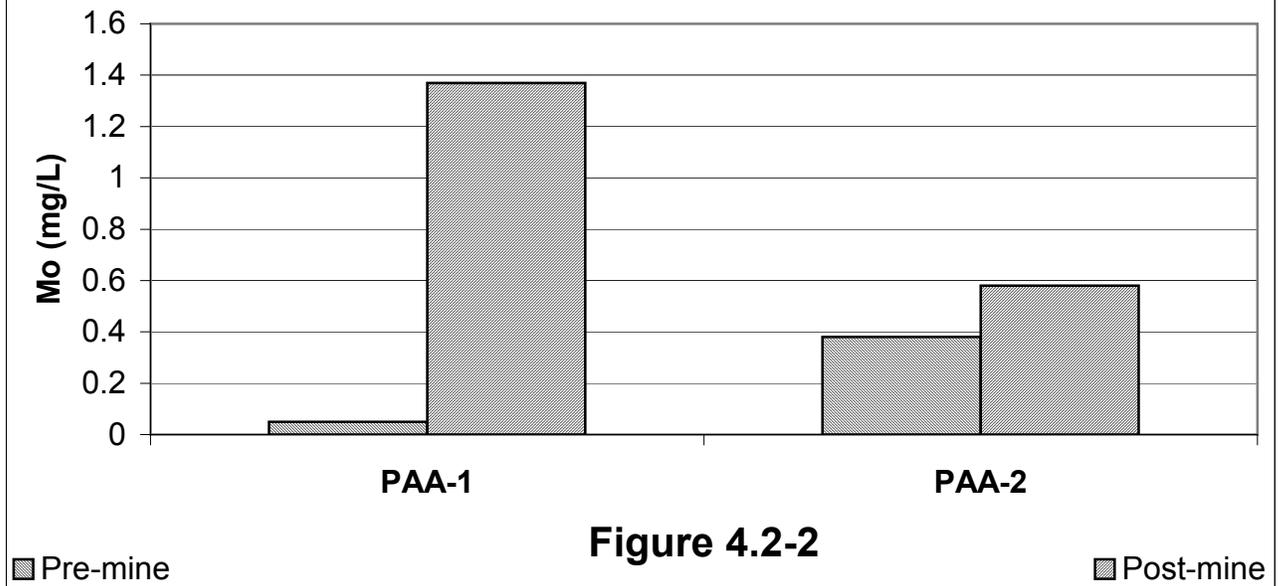


Figure 4.2-2

### Average Pre-mining and Post-mining Uranium Concentrations in Baseline Wells

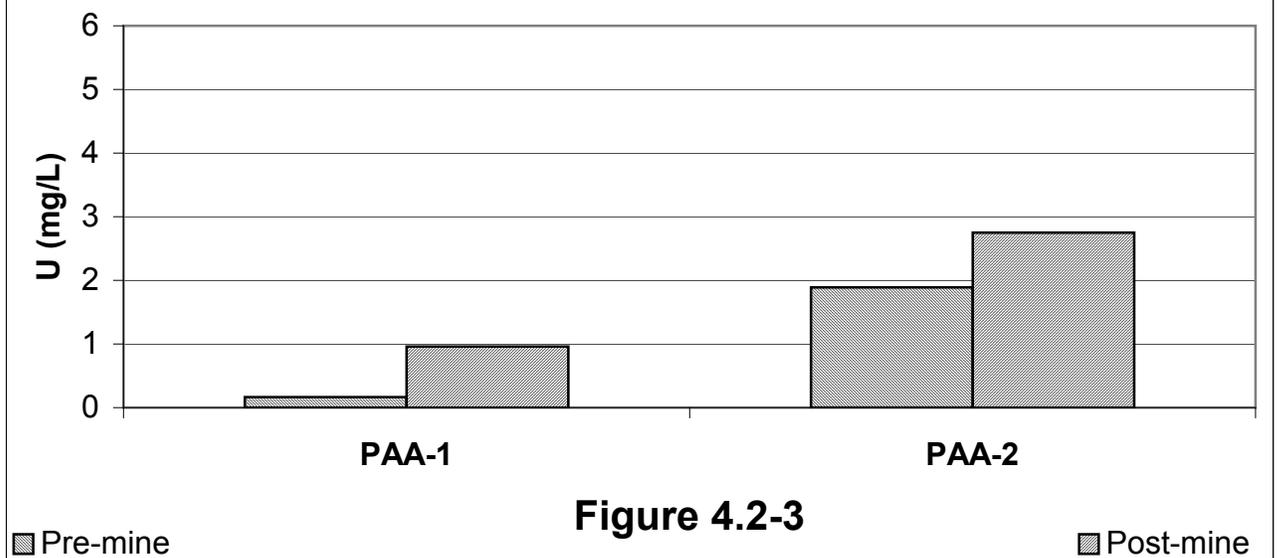


Figure 4.2-3

### 4.3 Groundwater Sampling

URI does two things that raise questions about the reliability of their sample analyses. First, they extract the samples from the wells by airlift<sup>85</sup>. This involves pumping air into the water that is to be sampled. Second, they do not filter and preserve (acidify) the samples immediately after they are collected<sup>86</sup>. Instead, the samples are filtered and preserved at the analytical laboratory.

Airlifting may lower some concentrations by causing chemically reduced constituents such as iron to precipitate. As iron precipitates, other constituents, including uranium<sup>87</sup>, may co-precipitate with it (occlusion). Airlifting may also strip gasses such as radon out of solution before samples are collected.

URI has recommended a series of tests to compare samples collected by airlift and pump methods<sup>88</sup>. These tests would be useful. They should be designed in cooperation with the CRB.

Samples should be filtered and preserved immediately after they are removed from the well<sup>89</sup>. Failure to immediately preserve samples may allow some constituents to precipitate. Subsequent filtering would remove the precipitates, resulting in analytical results that are too low for the affected constituents. If samples are acidified prior to filtering, sediments in the sample may be dissolved, resulting in analytical results that are too high for the affected constituents<sup>90</sup>.

Groundwater sampling is also discussed in appendix H, responses to comment 5 and recommendation 2.

#### 4.3.1 Split Sampling

In February 2006 the CRB and URI split samples from nine wells on and near the KVD Mine<sup>91</sup>. The analytical results are generally the same, except the results for radon-222. The radon values reported by the CRB's laboratory are significantly higher than those reported by URI's laboratory. The split sample analyses are presented in appendix F.

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<sup>85</sup> URI, 2003a, page 1.

<sup>86</sup> Personal communication with Mark Pelizza of URI, January 30, 2006. Filtering is required for dissolved metals analyses. Samples to be analyzed for total metals are not filtered.

<sup>87</sup> Demuth and Schramke, 2006, page 24.

<sup>88</sup> See appendix H, responses to comment 5 and recommendation 2.

<sup>89</sup> EPA, 2002, page 47.

<sup>90</sup> The laboratory acidified the samples after they were filtered (Personal communication with Mark Pelizza of URI, January 30, 2006).

<sup>91</sup> Split samples are collected at the same time from the same source. Different laboratories analyze them. The samples should be nearly identical.

## 5.0 Excursions

Texas regulations governing in-situ mining state the following:

*Mining solutions shall be confined to the production zone within the area of designated production zone monitor wells<sup>92</sup>.*

An excursion is a violation of this requirement. An excursion is the movement of mining solutions beyond the ring of monitor wells installed around a PAA.

### 5.1 State Definition of Excursion

The State has established control parameters for the KVD Mine. These are: EC, chloride, and uranium<sup>93</sup>. Excursions are defined as an exceedance of the upper limit of any control parameter. The upper limits of the control parameters are<sup>94</sup>:

- EC: 125% of the maximum pre-mining value measured in a PAA.
- Chloride: 125% of the maximum pre-mining value measured in a PAA.
- Uranium: 5 mg/L plus the maximum pre-mining value measured in a PAA.

The control parameter upper limits for each PAA are listed in table 5.1-1.

**Table 5.1-1  
Control Parameter Upper Limits**

PAA	EC (µmhos/cm)	Chloride (mg/L)	Uranium (mg/L)
1 <sup>95</sup>	2625	440	5.927
2 <sup>96</sup>	2525	420	8.75
3 <sup>97</sup>	3525	554	6.54

URI has identified excursions in two monitor wells: MW-49A and MW-172<sup>98</sup>. Between April 1998 and February 1999, EC and chloride values in these wells were higher than the upper limits<sup>99</sup>. Uranium exceeded the upper limit on one occasion in MW-172<sup>100</sup>, but did not exceed the upper limit in MW-49A.

<sup>92</sup> TAC Title 30, Part 1, Chapter 331, Subchapter F, §331.102.

<sup>93</sup> TWC, 1990a, page 4.

<sup>94</sup> TWC, 1990a, pages 4 and 5.

<sup>95</sup> TWC, 1988a, page 5, Attachment B.

<sup>96</sup> TWC, 1990b, page 4, Attachment B.

<sup>97</sup> TWC, 1998, page 5, Attachment B.

<sup>98</sup> URI, 2004, pages ER-39 and ER-40. These wells are in PAA-2.

<sup>99</sup> Maximum EC values measured in MW-49A and MW-72 were 4150 µmhos/cm and 5140 µmhos/cm, respectively (URI, 2005I). Maximum chloride values measured in MW-49A and MW-72 were 667 mg/L and 925 mg/L, respectively (URI, 2005I).

<sup>100</sup> The uranium concentration on 7/24/98 was 11.5 mg/L (URI, 2005I).

There are problems with the control parameter upper limits established by the State.

First, they are arbitrary. Merely multiplying the highest measured value by an arbitrary factor, or adding an arbitrary number to the highest measured value is not an approach that is based on the entire body of available data. It does not account for the statistical properties of the parameter population, and may result in the upper limit being determined by a single unusual value (see discussion of well 9310 below).

Second, some of the pre-mining EC measurements appear to be too high. For example, the highest pre-mining EC measured in any baseline well at the KVD Mine was 2820  $\mu\text{mhos}$  (PAA-3 baseline well 9310, 4/22/98)<sup>101</sup>. However, less than two months later a second pre-mining EC measurement for this same well yielded a value of 1740  $\mu\text{mhos}$  (6/8/98)<sup>102</sup>. It is unusual for EC values to vary this much unless one of the measurements is wrong or something has occurred to affect the quality of groundwater in the well. The higher value is more than 15% higher than any other pre-mining EC value measured at PAA-3<sup>103</sup>. Nonetheless, the control parameter upper limit for EC at PAA-3 is based on a value of 2820  $\mu\text{mhos}$ .

Third, the State's control parameters seem to be biased against the declaration of excursions. This bias can be seen in the EC values for MW-50. MW-50 is next to MW-49A and MW-172, the wells where excursions have been acknowledged by URI. EC values in all three wells rose significantly between April and July 1998<sup>104</sup> (figures 5.1-1 through 5.1-3). It seems clear that all of these wells are responding to the same event, i.e., an excursion of mining solutions from PAA-2. However, according to the State's definition, an excursion did not occur at MW-50 because the highest EC value measured in MW-50 was 2500  $\mu\text{mhos}$ , while the upper limit for EC at PAA-2 is 2525  $\mu\text{mhos}$ .

Finally, the monitor wells that are supposed to detect excursions are ill suited to that purpose. Many monitor wells are screened across 100 feet or more of the aquifer<sup>105</sup>. Thus, mining solutions that reach them are subject to dilution as they are sampled. A series of nested wells with shorter screen lengths would be more likely to detect excursions.

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<sup>101</sup> URI, 1997a, section titled *Ground Water Analysis Reports*.

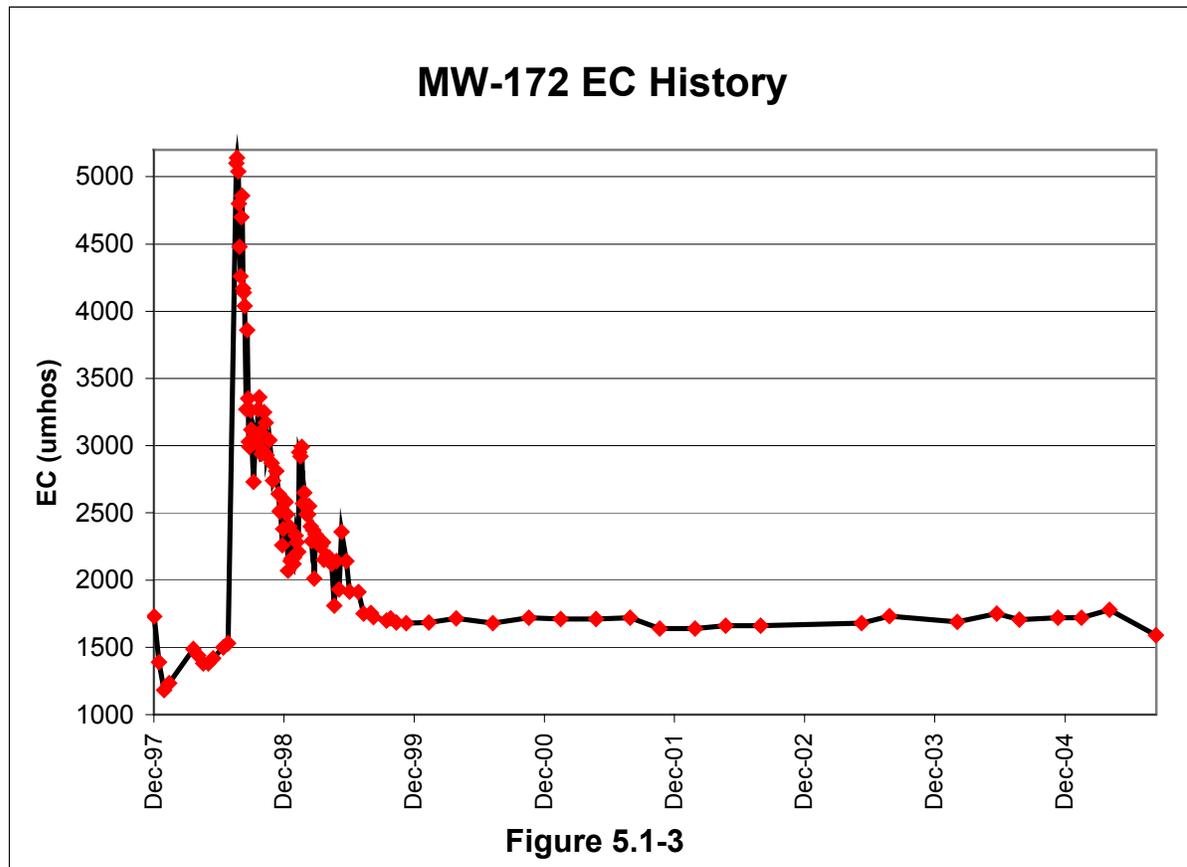
<sup>102</sup> URI, 1997a, section titled *Ground Water Analysis Reports*.

<sup>103</sup> Next highest value = 2390  $\mu\text{mhos}$  at well BL-8502 (see table 7.3.3.3-1).

<sup>104</sup> URI, 2005l.

<sup>105</sup> See, for example, URI 1997b, section titled Well Logs, Completion Reports, and M.I. Tests.





## 5.2 Alternate Definition of Excursion

Control parameters can be established in a less arbitrary manner. One common method of detecting contamination is calculation of the 95% upper tolerance limit (UTL)<sup>106</sup>. UTLs were calculated for the pre-mining monitor well EC data in each PAA<sup>107</sup>. The results are presented in table 5.2-1 and the calculations are presented in appendix C.

<sup>106</sup> EPA, 1989. The EPA describes the significance of the UTL (tolerance interval) as follows. "A tolerance interval is constructed from the data on (uncontaminated) background wells. The concentrations from compliance wells are then compared with the tolerance interval. With the exception of pH, if the compliance concentrations do not fall in the tolerance interval, this provides statistically significant evidence of contamination." (EPA, 1989, pages 5-20 – 5-21). It is important to note that all background data may not fall below the UTL. When using a 95% UTL, 5% of the background data may exceed the UTL (EPA, 1989, page 5-21).

<sup>107</sup> Only data from monitor wells are used to calculate the UTLs because excursions are only determined for monitor wells. The State's control parameter upper limits are calculated using data from both monitor and baseline wells.

**Table 5.2-1  
95% Upper Tolerance Limits for EC**

PAA	UTL ( $\mu\text{mhos}$ )
1	1736
2	1892
3	2585

These UTLs may be used to define excursions from each PAA<sup>108</sup>. In the discussion below, an excursion is defined as the exceedance of the EC UTL in at least three consecutive measurements. While this definition is still arbitrary to some degree, it accounts for the statistical properties of the EC population, and prevents the definition from being determined by a single, unusually high, value.

Table 5.2-2 lists the monitor wells where, based on the EC UTLs, excursions have occurred.

Figures 5.2-1 through 5.2-3 show examples of excursions based on the 95% UTL for EC.

It should be noted that some of the EC values used to calculate the UTLs appear to be too high. For example, the highest pre-mining EC measured in any monitor well was 2590  $\mu\text{mhos}$  (MW-86, PAA-3)<sup>109</sup>. However, since the pre-mining sample was collected, the average EC value at MW-86 has been 1693  $\mu\text{mhos}$  and the highest EC measurement has been 2120  $\mu\text{mhos}$ <sup>110</sup>. A similar set of facts applies to the monitor wells with the highest pre-mining EC values in PAA-1 (MW-15<sup>111</sup>) and PAA-2 (MW-48<sup>112</sup>). If pre-mining EC measurements are too high, UTLs that are based on them will also be too high. This would result in the identification of fewer excursions than have actually occurred.

<sup>108</sup> The 95% UTL must be used with care, as up to 5% of background values may exceed the UTL (EPA, 1989, page 5-21).

<sup>109</sup> Sample collected 4/7/97 (URI1997b, section titled *Ground Water Analysis Reports*).

<sup>110</sup> URI, 2005l.

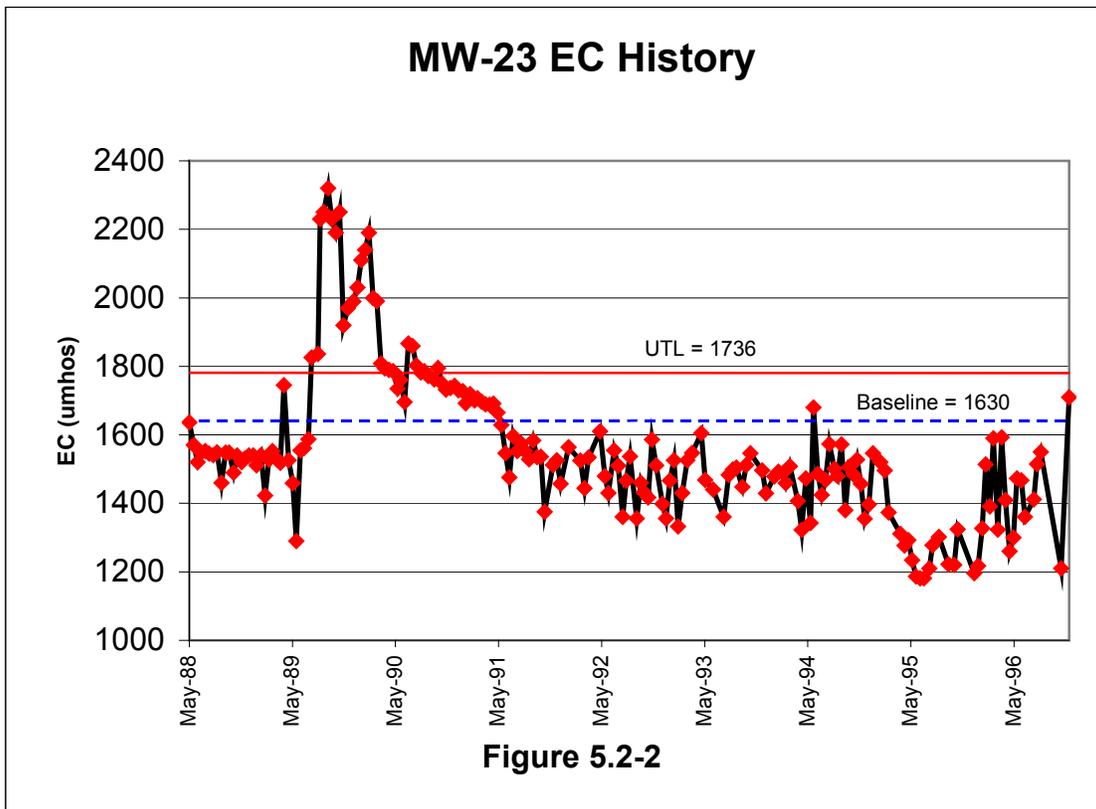
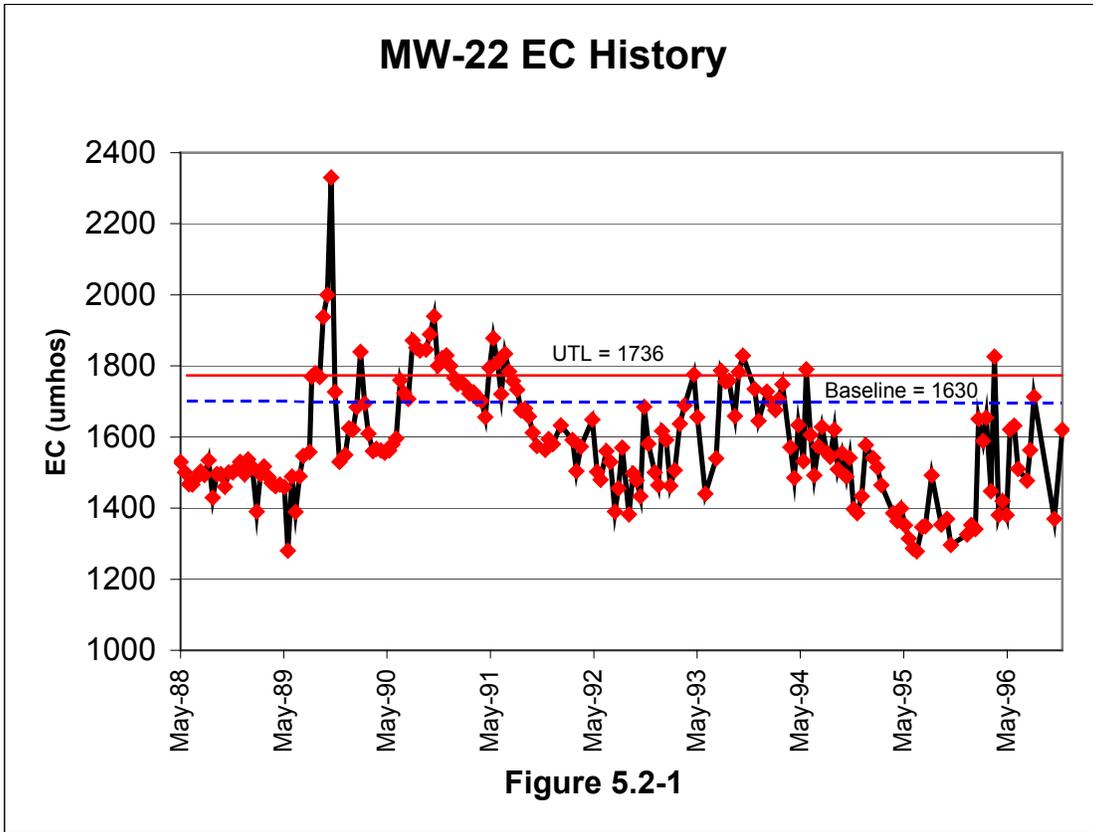
<sup>111</sup> MW-15: pre-mining EC = 1730  $\mu\text{mhos}$  (URI, 1987a, section titled *Ground Water Analysis Reports*). Average post-mining EC = 1569  $\mu\text{mhos}$ ; maximum post-mining EC = 1652  $\mu\text{mhos}$  (URI, 2005l). Note: the post-mining values are for samples collected in the first five years after mining began; May 1988 – May 1993.

<sup>112</sup> MW-48: pre-mining EC = 2020  $\mu\text{mhos}$  (URI, 1989a, section titled *Ground Water Analysis Reports*). Average post-mining EC = 1522  $\mu\text{mhos}$ ; maximum post-mining EC = 1740  $\mu\text{mhos}$  (URI, 2005l). Note: the post-mining values are for samples collected prior to the beginning of restoration, January 2002. The EC control parameter for PAA-2 is based on the EC value of 2020  $\mu\text{mhos}$  for well MW-48.

**Table 5.2-2  
Excursions, Based on 95% Upper Tolerance Limits for EC**

Well ID	Pre-mining EC (µmhos)	EC UTL (µmhos)	Maximum EC During Excursion (µmhos)	Excursion Duration
MW-3	1725	1736	1780	6/90 – 12/90
MW-10	1614	1736	2020	11/98 – 12/98
MW-15	1730	1736	2220	1/98 – 4/98
MW-22	1630	1736	2330 1940 1878 1787	8/89 – 10/89 8/90 – 2/91 4/91 – 7/91 7/93 – 8/93
MW-23	1630	1736	2320 1859	7/89 – 4/90 7/90 – 10/90
MW-24	1670	1736	1924 2120	1/90 – 2/90 7/90 – 4/91
MW-49A	NA <sup>113</sup>	1892	4150	4/98 – 3/00
MW-50	1610	1892	2500	6/98 – 6/99
MW-172	NA	1892	5140	7/98 – 6/99
MW-61	1570	1892	2210 2080	12/98 – 10/99 1/01 – 10/01
MW-72	2350	2585	2770	2/99 – 3/99
MW-74	2420	2585	2740	2/99 – 3/99
MW-88	2240	2585	3020 3040 2990 3060	10/99 – 2/00 10/00 – 5/01 1/02 - 7/02 1/04 – 10/04
MW-89	2410	2585	2840 2770	1/02 - 7/02 1/04 – 7/04
MW-95	1900	2585	2740	5/03 – 1/04

<sup>113</sup> Not available.



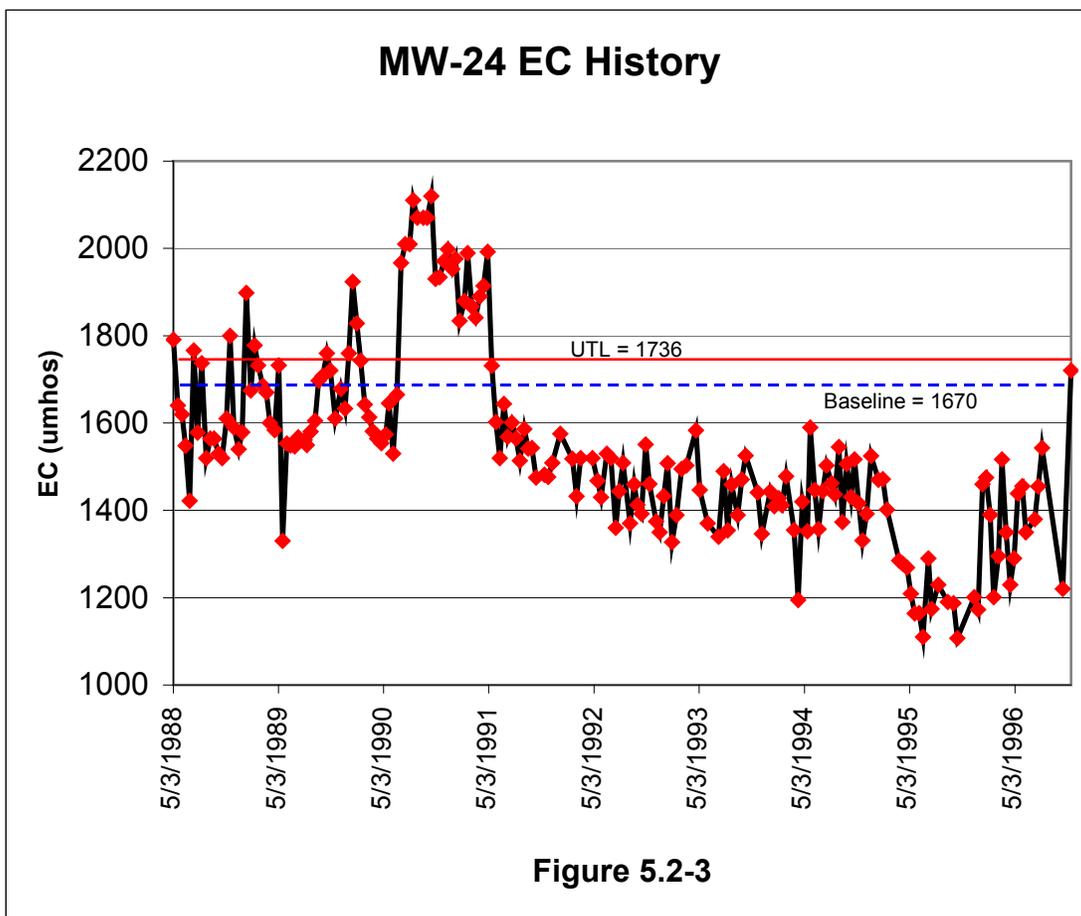


Figure 5.2-3

### 5.3 Excursions, Conclusion

The State's method of defining excursions is arbitrary, is subject to being dominated by unusual parameter values, and is biased against declaring excursions. In addition, the monitor wells used to detect excursions are not well suited to that purpose. According to the State's definition, excursions have occurred at two monitor wells.

This report presents an alternate definition of excursions based on EC UTLs<sup>114</sup>. This definition accounts for the statistical properties of the EC population and prevents the definition from being determined by a single, unusually high value. The drawback to using the 95% UTL is that up to 5% of the background values may exceed the UTL. According to this alternate definition, excursions have occurred at 15 monitor wells.

Excursions are also discussed in appendix H, responses to comments 6, 7, and 8.

<sup>114</sup> The same type of definition could, and should, be applied to the chloride and uranium data.

## 6.0 Effect of Mining on Nearby Domestic Wells

URI has monitored private domestic wells near the KVD Mine since 1983<sup>115</sup> (figure 2.0-4). In 1983 URI sampled nine domestic wells (table 6.0-1). These wells were to the south, east, and west of the initial mine license area.

URI does not appear to have sampled any domestic wells between 1983 and 1988.

URI currently samples five domestic wells on a quarterly basis<sup>116</sup>. However, there are additional wells in the area that could be sampled. URI has proposed conducting additional sampling domestic wells near the KVD Mine<sup>117</sup>. The additional sampling should include some of the wells that are not currently being sampled.

**Table 6.0-1  
Domestic Wells Sampled by URI<sup>118</sup>**

Well ID	Number of Samples Collected	Date of First Sample	Date of Last Sample
W.E. Cumberland	38	June 1983	December 2005
A.M. Cumberland	1	June 1983	June 1983
W. Palercio	1	June 1983	June 1983
Stanley Dietz	1	June 1983	June 1983
F. Radford	40	June 1983	December 2005
L.L. Radford	38	June 1983	June 1999
P. Perez	1	June 1983	June 1983
J.L. Robertson	54	June 1983	December 2005
B. Bippert	1	June 1983	June 1983
A. Garcia <sup>119</sup>	1	March 1988	March 1988
Garcia 24/25 <sup>120</sup>	29	April 1997	December 2005
Lehman	9	December 2003	December 2005

The quality of water in the domestic wells near the KVD Mine is marginal. TDS exceeds the EPA secondary drinking water standard of 500 mg/L in all wells

<sup>115</sup> TBRC, 1985, table 2.7-5.

<sup>116</sup> W.E. Cumberland, Garcia 24/25, F. Radford, J.L. Robertson, and Lehman (URI, 2006c).

<sup>117</sup> See appendix H, response to recommendation 1.

<sup>118</sup> Information from; TBRC, 1985, table 2.7-5; URI, 2004, attachments 1 – 5; and URI, 2005q.

<sup>119</sup> Data provided by Mark Walsh, personal communication, October 2005.

<sup>120</sup> Garcia 24/25 is a mixture of water from two wells. These wells are no longer used for domestic purposes (Mark Pelizza of URI, December 2005).

(table 6.0-2)<sup>121</sup>. However, with two exceptions, no constituents have exceeded the EPA primary drinking water standards in any domestic well. The exceptions occurred in the P. Perez well and the Garcia 24/25 wells.

In the P. Perez well, radium-226 exceeded the EPA primary drinking water standard of 5 pCi/L<sup>122</sup> (table 6.0-2). This sample was collected in 1983, approximately five years before the KVD Mine began operating. Thus, the mine did not cause the high radium-226.

**Table 6.0-2**  
**Domestic Wells Water Quality**<sup>123</sup>

Well ID	EC (µmhos)			Uranium (mg/L)		
	Minimum	Average	Maximum	Minimum	Average	Maximum
W.E. Cumberland	1430	1593	1730	0.009	0.012	0.019
A.M. Cumberland	868* <sup>124</sup>	868*	868*	0.025	0.025	0.025
W. Palercio	832*	832*	832*	0.009	0.009	0.009
Stanley Dietz	824*	824*	824*	0.007	0.007	0.007
F. Radford	1580	1640	1760	<0.001	0.009	0.017
L.L. Radford	1600	1659	1810	<0.001	0.005	0.014
P. Perez	956*	956*	956*	0.013	0.013	0.013
J.L. Robertson	1510	2022	4320	<0.001	<0.001	0.008
B. Bippert	992*	992*	992*	0.002	0.002	0.002
A. Garcia <sup>125</sup>	1640	1640	1640	0.011	0.011	0.011
Garcia 24/25 <sup>126</sup>	1430	1627	1760	0.141	0.195	0.636
Lehman	2085	2125	2200	<0.001	0.0007	0.001

<sup>121</sup> ECs are given in table 6.0-2 because TDS values are not available for some of the wells. However, given the high EC values measured in these wells, it is very likely that TDS exceeds the EPA secondary standard of 500 mg/L.

<sup>122</sup> EPA, 2004.

<sup>123</sup> Information from; TBRC, 1985, table 2.7-5; URI, 2004, attachments 1 – 5; URI, 2005q; and URI, 2006c. For averaging, non-detects assumed to be one half of detection limit.

<sup>124</sup> \* Value for TDS. EC values unavailable.

<sup>125</sup> Data provided by Mark Walsh, personal communication, October 2005.

<sup>126</sup> Garcia 24/25 is a mixture of water from two wells (Mark Pelizza of URI, December 2005).

**Table 6.0-2  
Domestic Wells Water Quality (concluded)**

Well ID	Radium-226 (pCi/L)		
	Minimum	Average	Maximum
W.E. Cumberland	0	0.25	0.9
A.M. Cumberland	0.34	0.34	0.34
W. Palercio	0.44	0.44	0.44
Stanley Dietz	0.59	0.59	0.59
F. Radford	0	0.2	1.2
L.L. Radford	0.1	0.22	0.7
P. Perez	7.17	7.17	7.17
J.L. Robertson	0	0.2	0.7
B. Bippert	0.52	0.52	0.52
A. Garcia <sup>127</sup>	1.1	1.1	1.1
Garcia 24/25 <sup>128</sup>	0.4	0.77	1.3
Lehman	0.1	0.52	2.9

In the Garcia 24/25 wells, uranium exceeded the EPA primary drinking water standard of 0.03 mg/L<sup>129</sup> in all 29 samples (table 6.0-2). However, the mine did not cause the high uranium.

Garcia wells 24/25 are a few hundred feet northwest of PAA-3. High uranium concentrations were detected in the wells in April 1997. Mining did not begin in PAA-3 until June 1998. In addition, the uranium concentrations in Garcia 24/25 are similar to naturally occurring uranium concentrations at PAA-3. Background uranium concentrations are as high as 0.187 mg/L in monitor wells and as high as 1.54 mg/L in baseline wells (tables 4.1-5 and 4.1-6). Finally, according to maps produced by URI, the Garcia 24/25 wells are close to a uranium ore body<sup>130</sup>.

<sup>127</sup> Data provided by Mark Walsh, personal communication, October 2005.

<sup>128</sup> Garcia 24/25 is a mixture of water from two wells (Mark Pelizza of URI, December 2005).

<sup>129</sup> EPA, 2004.

<sup>130</sup> Some questions remain unanswered concerning wells on the Garcia property. Garcia 24/25 consists of two wells about 200 feet apart. The discharges from the wells are mingled before being sampled. One of the wells was installed by URI in 1989. The other well existed before 1989. To the best of URI's knowledge, neither of these wells was ever sampled separately (URI 2005r). Thus, it is not known whether one or both of the wells contain the high uranium concentrations. Although URI sampled the A. Garcia well in 1988, it does not know its location (per discussion with Mark Pelizza and Mike Maxson of URI, December 20<sup>th</sup>, 2005). URI does say, however, that the A. Garcia well is not either of the two wells designated as Garcia 24/25 (per discussion with Mark Pelizza and Mike Maxson of URI, December 20<sup>th</sup>, 2005). In addition, there are analytical records for wells designated Garcia #69A (5/22/87), Garcia #69B (5/22/87), and Garcia #69C (5/26/87) (analytical records provided by Mark Walsh, personal communication, October 2005). The uranium results for these wells were 0.05, 0.08, and 0.05, respectively (as U<sub>3</sub>O<sub>8</sub>). There are no units associated with the analyses but they are probably mg/L. URI does not know the locations of these wells or who collected these samples (URI 2005r). Finally, there is an

In early 1995 EC values in the J.L. Robertson well rose sharply, from approximately 1600  $\mu\text{mhos}$  to approximately 4000  $\mu\text{mhos}$ . The well is about 1000 feet east of PAA-1 (figure 2.0-4). Such a rise could be caused by the movement of mining solutions from PAA-1 into the Robertson well. However, from 1988 to 1996, EC measurements in the monitor wells between PAA-1 and the Robertson well never exceeded 2000  $\mu\text{mhos}$ <sup>131</sup>. Thus, PAA-1 is probably not the cause of the rise in EC levels. URI has explained the rise as being due to a leak in the well casing that allowed poor quality water from the overlying 'E' sand to enter the well<sup>132</sup>. EC's in E sand wells range from 10,800  $\mu\text{mhos}$  to 15,100  $\mu\text{mhos}$ <sup>133</sup>. URI's explanation is consistent with the available data.

### 6.1 Domestic Wells, Conclusion

There is no reason to believe that any domestic well has been affected by mining solutions emanating from the KVD Mine.

### 7.0 Restoration

URI is required to restore groundwater quality after it completes mining in each PAA. Table 7.0-1 shows when restoration efforts began and ended in PAAs 1 and 2. URI has not begun restoring PAA-3<sup>134</sup>. A groundwater bleed<sup>135</sup> is maintained from all the PAAs to prevent excursions of mining solutions<sup>136</sup>.

Although URI stopped restoration at PAA-1 in 2004, groundwater at PAA-1 is not restored to the levels required by the State (see section 7.2.1). In addition, groundwater in the portions of PAAs 1 and 2 that are being re-mined will need to be restored after the re-mining is completed. URI has not produced new estimates of the time required to complete restoration in either PAA<sup>137</sup>.

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analytical record for Y.C. Garcia well (5/12/88). The uranium result for this well was 0.032 mg/L (natural) (TCEQ, 2005a, pages 127 – 130).

<sup>131</sup> Monitor wells MW-1 through MW-8 (URI, 2005i).

<sup>132</sup> URI, 2004, section 10.6.1.

<sup>133</sup> URI, 1989a, section titled *Ground Water Analysis Report Summary*.

<sup>134</sup> URI, 2005j, response to question 4.

<sup>135</sup> A bleed is pumping that causes groundwater to be drawn toward mining-affected areas. If the bleed works as intended, this would prevent the migration of mining-affected groundwater into other portions of the aquifer.

<sup>136</sup> URI, 2006b, page 9 of table titled *Kingsville Dome Restoration, Individual Well Summary, Update to Dec. 31, 2005*.

<sup>137</sup> Compare the restoration schedules in URI, 2005p; and TCEQ, 2006a.

**Table 7.0-1  
Restoration History for PAAs 1 and 2**

Production Area	Restoration Began	Restoration Ended
PAA-1	June 8, 1998 <sup>138</sup>	March 31, 2004 <sup>139</sup>
PAA-2	January 29, 2002 <sup>140</sup>	Ongoing

The production zone groundwater is restored by pumping it to the surface and treating it by reverse osmosis (RO). This results in a concentrated fraction (approximately 30% of the treated water)<sup>141</sup> and a relatively fresh fraction. The concentrated fraction is disposed in an on-site waste disposal well. The disposal well is completed in the Upper Frio Formation<sup>142</sup> (figure 2.0-3). The water is injected between 4150 feet and 5300 feet below land surface<sup>143</sup>.

The fresh fraction is routed to injection wells and reused in the restoration process. Table 7.0-2 shows concentrations of constituents in the fresh RO fraction.

**Table 7.0-2  
Concentrations of Constituents in Fresh RO Fraction<sup>144</sup>**

pH (SU)	EC (µmhos/cm)	Uranium (mg/L)	Chloride (mg/L)	Calcium (mg/L)	Bicarbonate (mg/L)	Sulfate (mg/L)	Molybdenum (mg/L)
6.5	327	0.061	60	6.8	55	23	0.07

During restoration the groundwater in the production zone is a mixture of remnants of the mining solution, the fresh RO fraction, and groundwater from the aquifer. Thus, although mining solutions contain elevated levels of several constituents (e.g., EC and uranium, table 4.2-1), there may be no correlation between these constituents in groundwater zones that are undergoing restoration. This lack of correlation is shown in figure 7.0-1, which depicts EC and uranium values in samples collected during restoration at PAA-1<sup>145</sup>.

<sup>138</sup> URI, 2005j, response to question 4; and URI, 1998a.

<sup>139</sup> Before re-mining began, URI stated that restoration may be resumed if required by State (personnel communication, Ron Grant of URI, January 6, 2006).

<sup>140</sup> URI, 2005j, response to question 4.

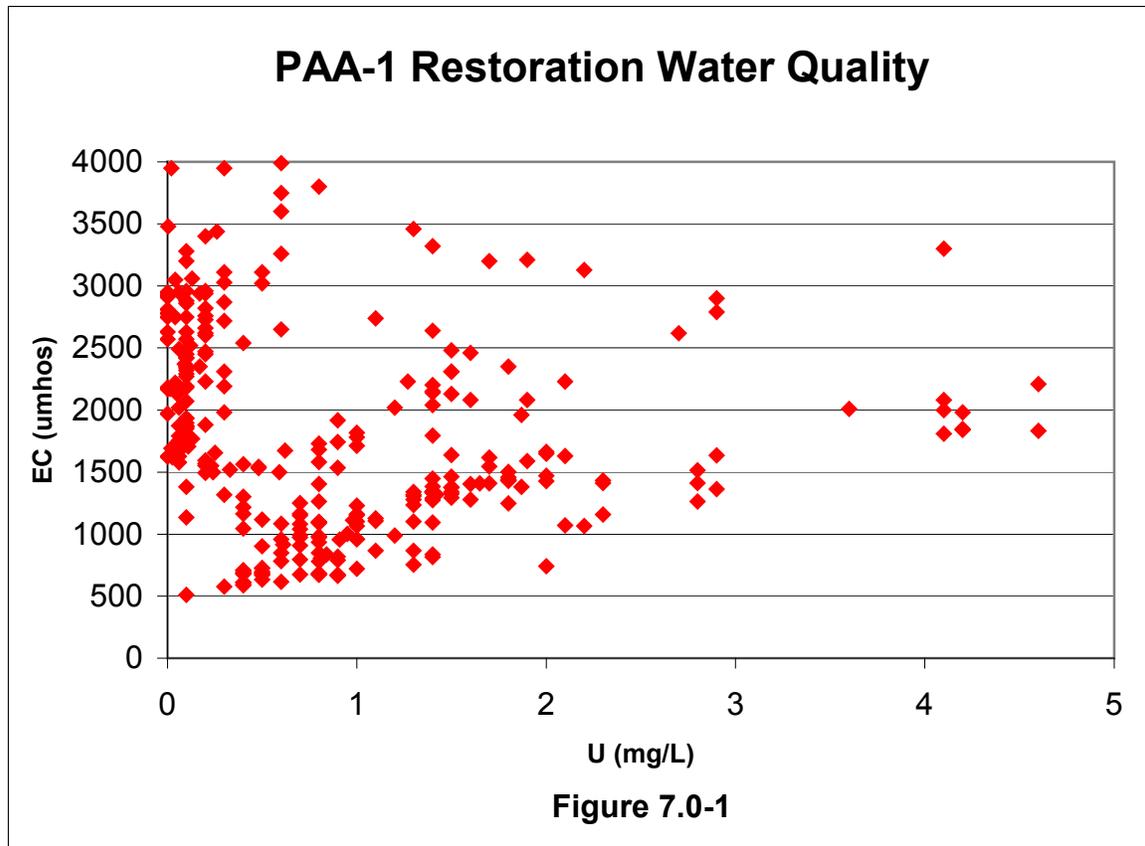
<sup>141</sup> URI, 2004, page ER-31.

<sup>142</sup> TWC, 1988b, page 1.

<sup>143</sup> TWC, 1988b, page 1. In the first quarter of 2006 a casing leak was discovered in the disposal well at a depth of 2100 feet. The leak has been repaired (URI, 2006e).

<sup>144</sup> Analysis of discharge from URI's reverse osmosis system, August 15, 2000. Analysis provided by Mark Pelizza of URI, December 2005.

<sup>145</sup> URI, 2005g. This figure does not show all samples collected during restoration in PAA-1. Samples with ECs greater than 4000 umhos or uranium concentrations greater than 5 mg/L are not shown.



### 7.1 Effectiveness of Restoration

The effectiveness of URI's restoration efforts was evaluated from three points of view:

- 1) Has URI complied with State restoration requirements?
- 2) Have URI's restoration efforts satisfied its agreement with Kleberg County?
- 3) Has URI restored the groundwater to the quality that existed before mining began?

Restoration was evaluated using water quality analyses from the baseline wells at PAAs 1, 2, and 3 (table 7.1-1)<sup>146</sup>. These wells were sampled before any production began in the PAA. Since restoration began, the baseline wells in PAAs 1 and 2 have been periodically sampled for eight parameters: pH, EC, uranium, chloride, calcium, bicarbonate, sulfate, and molybdenum (see tables 7.2.1-1 and 7.2.2-1).

<sup>146</sup> Although URI has not begun restoring PAA-3, baseline data from PAA-3 are included for completeness.

**Table 7.1-1  
Baseline Wells in PAAs 1, 2, and 3**

PAA-1 <sup>147</sup>	PAA-2 <sup>148</sup>	PAA-3 <sup>149</sup>	
EX-1	BL-547	BL-8501	9101
EX-2	BL-1047	BL-8502	9103
EX-3	BL-1240	BL-8503	9105
I-1	BL-1265	BL-8504	9107
I-2	BL-1491	BL-8505	9109
I-3		BL-8506	9111
I-4		BL-8507	9113
I-5		BL-8508	9302
I-6		BL-8509	9304
I-7		BL-8510	9306
I-8		BL-8511	9308
I-9			9310
I-10			9312
I-11 (aka 161)			9314
I-12 (aka PBL-4)			9315
I-13			9602

A problem with the State's restoration requirements is that they may apply to relatively few wells in each PAA<sup>150</sup>. For example, PAA-2 covers over 200 acres<sup>151</sup>. There are hundreds of production wells in PAA-2, but only five baseline wells. Clearly, restoring the five baseline wells to State standards will not guarantee that all areas of PAA-2 have been properly restored. Therefore, the State restoration requirements should be applied to all production wells in a PAA, not just to the baseline wells.

This raises the question of whether additional baseline wells should be designated. It may be reasonable to do so. However, care must be taken to ensure that any additional baseline wells have not been affected by mining operations. This issue is discussed in the following section.

<sup>147</sup> These baseline wells are listed in TWC, 1988a, page 10, Attachment G. Note – nomenclature for baseline wells is not consistent. For example, EX-1 is also referred to as 1EX. I1 is also referred to as I-1, etc. (compare analytical reports and figure 1 in 1987a). The additional identifiers for I-11 and I-12 are shown on the sample analysis reports (URI, 1987a).

<sup>148</sup> These baseline wells are listed in TWC, 1990b, page 9, Attachment G.

<sup>149</sup> These baseline wells are listed in TWC, 1998, page 6, Attachment C.

<sup>150</sup> State regulations do not clearly state which wells are required to be restored to standards. See 30TAC §331.107.

<sup>151</sup> TWC, 1990b, page 6.

### 7.1.1 Questionable Samples from ‘Supplementary Baseline Wells’

The initial samples collected from the baseline wells listed in table 7.1-1 were collected before mining began in the PAA. URI has also collected initial samples from ‘supplementary baseline wells’ after mining began in each PAA. URI defines supplementary baseline wells as: *Every extraction well in a new wellfield that gets a pump and is sampled before injection begins*<sup>152</sup>. URI claims that many of the samples from the supplementary wells represent baseline (pre-mining) conditions<sup>153</sup>.

However, some supplementary baseline wells may have been affected by mining solutions from injection wells operating in the PAA. Therefore, the claim that the initial samples from the supplementary wells represent baseline conditions should be closely examined.

Look, for example, at URI’s claim regarding the initial sample from supplementary well 5525 in PAA-2. According to URI this well had a baseline uranium concentration of 102 mg/L<sup>154</sup>. This is the highest pre-mining uranium concentration found in any KVD Mine well<sup>155</sup>. However, the initial sample was collected months after production began in PAA-2<sup>156</sup>. In addition there were five injection wells within a hundred feet of well 5525. These wells began injecting between 11 and 40 days before well 5525 was sampled. The injection rates ranged from 1400 to 218,800 gallons per day<sup>157</sup>.

Given the high hydraulic gradients associated with injection and extraction<sup>158</sup>, it is clearly possible for mining solutions from the injection wells to have reached well 5525 before it was sampled. Thus, URI’s claim that the initial sample from this well represents baseline conditions is questionable.

<sup>152</sup> Personal communication from Mark Pelizza of URI, June 20, 2006.

<sup>153</sup> See URI, 2006f, comment 10. The supplementary baseline wells are; in PAA-1: 4002, 4009, 4014, 4025, 4030, 4050-A, 4057, 4061, 4073-A, (note, the 4000-series wells are in PAA-2, not PAA-1 (URI, 2005u)), 7306, 7308, 7310, 7311, 7502, 7502A, 7504, 7504A, 7506A, 7507, 7512, 7516, 7521, 7525, and 7701; in PAA-2: 5119, 5120, 5132, 5133, 5134, 5135, 5137, 5350, 5354, 5356, 5370, 5372, 5425, 5430, 5525, 5534, 5552, 5553, 5556, 5557, 5558, 5559, 5560, 5562, 5566, 5567, 5570, 5577, 5705, 5707, 5710, 5711, 6136, 6141, 6147, 6150, 6171, 6172, 6174, 6178, 6179, 6210, 6212, 6314, 6350, 6362, 6364, 6445, 6460, 6466, 6468, 6470, 6472, 6474, 8303, 8305, 8306, 8507, 8508, 8509, 8510, 8511, 8512, 8514, 8515, 8516, 8517, 8518, 8519, 8522, 8523, 8701, 8702, 8703, 8708; and in PAA-3: 10101, 10104, 10106, 10109, 10113, 10115, 10301, 10303, 10310, 10311, 10312, 10314, 10316, 10318, 10320. List of baseline wells from URI, 2005e. Sample collection dates from URI, 1987a; URI 1989a; and URI, 1997a. The State recognizes only those wells listed in table 7.1-1 as baseline wells.

<sup>154</sup> URI, 1989a, uranium analysis for well 5525, in section titled *Ground water Analysis Reports (All Baseline and Monitor Wells)*.

<sup>155</sup> URI, 2005e.

<sup>156</sup> URI, 1989a, uranium analysis for well 5525, in section titled *Ground water Analysis Reports (All Baseline and Monitor Wells)*.

<sup>157</sup> URI, 2005b; and URI 2005c.

<sup>158</sup> URI refers to hydraulic gradients during operations as “extremely steep” (URI, 2005d).

A similar set of facts applies to supplementary well 5425 in PAA-2. This well had the second highest uranium concentration found in any baseline sample (66.2 mg/L)<sup>159</sup>. Again, URI's claim that this high uranium concentration represents baseline is questionable.

Additional information concerning injection in the vicinity of wells 5525 and 5425 is presented in appendix D.

There is another problem with some of the supplementary wells. Some of the chemical analyses are inconsistent. For example, there are two analyses for supplementary well 7512. Both analyses are for a sample collected on 9/24/97 at 3:20 pm<sup>160</sup>. In one analysis, the concentrations of uranium and molybdenum are given as 1.86 mg/L and 2.2 mg/L, respectively. In the other analysis, the concentrations of uranium and molybdenum are given as 0.248 mg/L and 1.7 mg/L, respectively. This raises an important question; what are the baseline concentrations at supplementary well 7512? In addition, the 'baseline' concentrations of chloride and sulfate at well 7512 are quite high (708 mg/L and 1580 mg/L, respectively). These high values suggest that well 7512 may have been affected by mining solutions before the baseline sample was collected.

If URI proposes to use data from any of the supplementary baseline wells, they should be required to show that the use of the data is appropriate. This showing should be required for the data from each well that URI proposes to use.

Supplementary baseline wells are also discussed in Appendix H, responses to comments 10 and 15.

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<sup>159</sup> URI, 2005e.

<sup>160</sup> The chemical analyses were performed on different dates. (URI 1987a, section titled *Ground Water Analysis Reports (All Baseline and Monitor Wells)*).

## 7.2 State Restoration Requirements

The State has established restoration requirements for all three PAAs at the KVD Mine<sup>161</sup>. These requirements are listed in the permits issued for each PAA (table 7.2-1). At the end of restoration, the average concentration of constituents in the baseline wells in each PAA must be less than the State requirements.

URI may ask the State to change the required restoration values. Although URI has not yet made such a request, they have indicated that such a request is 'inevitable'<sup>162</sup>. URI may ask the State to allow post-restoration concentrations as high as the upper values contained in the Restoration Range Table (appendix E). The State could grant such a request without holding a public hearing. However, if URI requests changes that exceed the upper values in the Restoration Range Table, a public hearing may be required<sup>163</sup>.

The baseline wells are sampled several times a year<sup>164</sup>. However, URI does not sample the baseline wells for all of the constituents listed in table 7.2-1. They sample the wells only for the eight constituents listed in tables 7.2.1-1 and 7.2.2-1. The values given in these tables are from the most recent analyses available for each baseline well (1<sup>st</sup> quarter of 2006).

The re-mined area straddles the boundary of PAAs 1 and 2. URI sampled 'baseline' wells in the area before re-mining began in April 2006. Unfortunately, many of these baseline wells are in areas that have already been mined<sup>165</sup>. Therefore, it is possible that samples collected from these wells have been affected by mining solutions from past operations.

If there are no independent baseline wells for the re-mined area, what restoration requirements should be applied? A straightforward solution would be to apply the requirements for each PAA to the production wells in that PAA. That is, the restoration requirements for PAA-1 would be applied to the re-mining wells in PAA-1, and the restoration requirements for PAA-2 would be applied to the re-mining wells in PAA-2.

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<sup>161</sup> Regulations governing restoration at in-situ mining operations are contained in TAC Title 30, Part 1, Chapter 331, Subchapter F, §331.104 and §331.107.

<sup>162</sup> URI, 2005d, item 2.

<sup>163</sup> Mark Pelizza, personal communication, December 2005.

<sup>164</sup> URI, 2006b.

<sup>165</sup> URI, 2005u.

**Table 7.2-1  
State Restoration Requirements for PAAs 1, 2, and 3**

<b>Constituent</b>	<b>Units</b>	<b>PAA-1<sup>166</sup></b>	<b>PAA-2<sup>167</sup></b>	<b>PAA-3<sup>168</sup></b>
Calcium	mg/L	20.8	25.3	18
Magnesium	mg/L	5.1	5.5	6.9
Sodium	mg/L	344	323	404
Potassium	mg/L	7.67	8.2	16
Carbonate	mg/L	38	7	NA <sup>169</sup>
Bicarbonate	mg/L	268	327	232
Sulfate	mg/L	204	224	364
Chloride	mg/L	234	224	289
Fluoride	mg/L	0.56	0.65	0.6
Nitrate (as N)	mg/L	0.75	0.89	0.89
Silica	mg/L	17.9	27	20
PH	SU <sup>170</sup>	8.74	7.37 – 8.66	6 - 9
TDS <sup>171</sup>	mg/L	997	1035	1221
EC <sup>172</sup>	µmhos	1717	1662	2017
Alkalinity	mg/L <sup>173</sup>	272	280	191
Arsenic	mg/L	0.005	0.006	0.009
Cadmium	mg/L	0.01	0.0002	0.0001
Iron	mg/L	0.04	0.03	0.02
Lead	mg/L	0.02	0.004	0.003
Manganese	mg/L	0.01	0.02	0.01
Mercury	mg/L	0.001	0.0001	0.0001
Selenium	mg/L	0.007	0.014	0.014
Ammonia	mg/L	1.06	0.15	0.18
Molybdenum	mg/L	0.06	0.38	0.33
Radium 226	pCi/L	21.63	92	21.6
Uranium	mg/L	0.164	1.89	0.338

<sup>166</sup> TWC, 1988a, Attachment A, Restoration Table.

<sup>167</sup> TWC, 1990b, attachment A, Restoration Table.

<sup>168</sup> TWC, (1998), attachment A, Restoration Table.

<sup>169</sup> Not available

<sup>170</sup> SU = standard units.

<sup>171</sup> TDS = total dissolved solids.

<sup>172</sup> EC = electrical conductivity.

<sup>173</sup> The units for alkalinity are listed as "Std. Units". It is assumed that this means mg/L as CaCO<sub>3</sub>.

### 7.2.1 PAA-1

In PAA-1 URI has failed to meet the State restoration requirements for all seven constituents (EC, uranium, chloride, calcium, bicarbonate, sulfate, and molybdenum; table 7.2.1-1).

If the State agreed to change the required restoration values and allow concentrations as high as the upper values in the Restoration Range Table, PAA-1 would meet the relaxed requirements for five constituents (EC, uranium, chloride, bicarbonate, and sulfate) and would not meet the relaxed requirements for three constituents (pH, calcium, and molybdenum; table 7.2.1-1).

In a letter to Kleberg County Judge De La Garza, URI stated: *PAA1 is now restored to the values that are consistent with baseline average and as required by the rules of the TCEQ.*<sup>174</sup> This is not correct. Additional restoration must be performed before PAA-1 meets the State's (TCEQ's) restoration requirements.

In addition, URI is re-mining a portion of PAA-1. The re-mined area will require restoration after re-mining is complete. URI has not yet provided an estimate of when restoration at PAA-1 will be completed<sup>175</sup>.

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<sup>174</sup> URI, 2005p, page 1.

<sup>175</sup> TCEQ, 2006a, page 10.

**Table 7.2.1-1  
PAA-1 Baseline Wells  
Post-mining Water Quality<sup>176</sup>**

Baseline Well ID	Date	pH (SU)	EC (µmhos/cm)	Uranium (mg/L) <sub>177</sub>	Chloride (mg/L)	Calcium (mg/L)	Bicarbonate (mg/L)	Sulfate (mg/L)	Molybdenum (mg/L)
EX-1 <sup>178</sup>	-	-	-	-	-	-	-	-	-
EX-2	2/9/06	7.8	2590	1.53	253	166	376	655	0.01
EX-3	2/27/06	6.7	1441	1.78	160	151	383	165	0.06
I-1	2/9/06	6.9	2670	0.509	339	226	421	632	1.50
I-2	2/9/06	7.8	1619	0.093	239	386	402	154	0.01
I-3	2/27/06	7.0	2730	2.63	339	229	434	361	0.04
I-4	2/9/06	7.0	1785	0.0	246	220	377	297	1.60
I-5	2/9/06	6.8	1466	2.04	160	138	371	269	2.10
I-6 <sup>179</sup>	2/27/06	10.6	4270	0.085	1210	396	634	69	0.04
I-7	2/9/06	7.2	2010	0.085	273	207	377	354	3.80
I-8	2/9/06	7.0	1135	0.636	133	339	333	142	1.00
I-9	2/9/06	6.8	1677	0.932	140	201	390	422	2.60
I-10	2/9/06	7.4	1443	0.195	146	298	484	136	3.50
I-11	2/9/06	6.8	1197	1.27	100	273	346	226	1.60
I-12	2/9/06	6.9	3300	0.0	346	220	465	495	2.20
I-13	2/9/06	7.5	1544	2.63	240	254	320	127	0.55
Average	-	7.35	2058	0.961	288	247	408	300	1.37
State Requirement <sup>180</sup>		8.74 <sup>181</sup>	1717	0.164	234	20.8	268	204	0.06
Meets State Requirement?		-	No	No	No	No	No	No	No
State Restoration Range Table Upper Value		7.37 – 9.5	2100	1.89	352	74	505	310	0.84
Less Than Upper Value?		No <sup>182</sup>	Yes	Yes	Yes	No	Yes	Yes	No

<sup>176</sup> Last available analysis, URI, 2006e. There are some discrepancies in this document between the values listed in table 1 and the values given on the sheets for each well. According to URI, the values on the sheets for each well are correct (personal communication, Ron Grant of URI, June 20, 2006).

<sup>177</sup> Value converted from U<sub>3</sub>O<sub>8</sub> by multiplying by 0.848.

<sup>178</sup> Unable to obtain sample since 7/2/01, URI, 2005i.

<sup>179</sup> First sample collected since 11/20/02, URI, 2006e.

<sup>180</sup> State restoration requirements are listed in table 7.2-1.

<sup>181</sup> The meaning of this requirement is unclear. It is not known whether pH values higher or lower than this value would violate the restoration requirement. For PAAs 2 and 3, the State restoration requirement is a range rather than a single value (table 7.2-1).

<sup>182</sup> pH must be within the given range.

### 7.2.2 PAA-2

In PAA-2 URI has failed to meet the State restoration requirements for all eight constituents (pH, EC, uranium, chloride, calcium, bicarbonate sulfate, and molybdenum; table 7.2.2-1).

If the State agreed to change the required restoration values and allow concentrations as high as the upper values in the Restoration Range Table, PAA-2 would meet the relaxed requirements for bicarbonate and molybdenum, but would not meet the relaxed requirements for the other six constituents (pH, EC, uranium, chloride, calcium, and sulfate; table 7.2.2-1).

URI is continuing groundwater restoration work in PAA-2. Before re-mining began, URI estimated that restoration would be completed in mid-2008<sup>183</sup>. URI has not revised this estimate<sup>184</sup>.

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<sup>183</sup> URI, 2005h, response to question 2; and URI, 2005p, page 3.

<sup>184</sup> TCEQ, 2006a, page 10.

**Table 7.2.2-1  
PAA-2 Baseline Wells  
Post-mining Water Quality <sup>185</sup>**

Baseline Well ID	Date	pH (SU)	EC (µmhos/cm)	Uranium (mg/L) <sup>186</sup>	Chloride (mg/L)	Calcium (mg/L)	Bicarbonate (mg/L)	Sulfate (mg/L)	Molybdenum (mg/L)
BL-547 <sup>187</sup>	5/31/06	6.8	4940	9.50	692	358	695	1376	1.86
BL-1047 <sup>188</sup>	2/27/06	6.9	3630	0.170	891	270	94	394	0.05
BL-1240	2/9/06	7.4	1785	0.170	246	693	352	301	0.63
BL-1265	2/27/06	6.8	1518	1.27	166	166	421	204	0.12
BL-1491	2/9/06	7.6	1580	2.63	240	370	377	226	0.26
Average	-	7.1	2691	2.75	447	371	388	500	0.58
State Requirement <sup>189</sup>		7.37 – 8.66	1662	1.89	224	25.3	327	224	0.38
Meets State Requirement?		No	No	No	No	No	No	No	No
State Restoration Range Table Upper Value		7.37 – 9.5	2100	1.89	352	74	505	310	0.84
Less Than Upper Value?		No <sup>190</sup>	No	No	No	No	Yes	No	Yes

<sup>185</sup> Last available analysis, URI, 2006b. There are some discrepancies in this document between the values listed in table 1 and the values given on the sheets for each well. According to URI, the values on the sheets for each well are correct (personal communication, Ron Grant of URI, June 20, 2006).

<sup>186</sup> Value converted from U<sub>3</sub>O<sub>8</sub> by multiplying by 0.848.

<sup>187</sup> Data for BL-547 provided by Ron Grant of URI, June 21, 2006. All data are for a sample collected on 5/31/06, except for the molybdenum value. The molybdenum value is for a sample collected on 2/9/06.

<sup>188</sup> First sample collected since 8/9/04 (URI, 2006e).

<sup>189</sup> State restoration requirements are listed in table 7.2-1.

<sup>190</sup> pH must be within the given range.

### 7.2.3 State Restoration Requirements, Conclusion

URI has not satisfied the State restoration requirements at either PAA-1 or PAA-2.

URI has indicated that they will ask the State to change the restoration requirements<sup>191</sup>. However, even if the State agreed to allow concentrations as high as the upper values in the Restoration Range Table, PAA-1 would fail to meet the relaxed requirements for pH, calcium, and molybdenum. PAA-2 would fail to meet the relaxed requirements for pH, EC, uranium, chloride, calcium, and sulfate. Under these circumstances URI may 1) continue restoration until the Restoration Range Table requirements are satisfied, or 2) ask the State to change the Restoration Range Table. A public hearing may be required to change the Restoration Range Table.

It is possible that samples collected from baseline wells in the re-mined areas have been affected by mining solutions from past operations. Therefore, unless URI can show that these wells have not been affected by past operations, they should not be used to establish baseline conditions in the re-mined area. The restoration requirements for each PAA should be applied to the re-mining wells in each PAA.

### 7.3 County Restoration Requirements

Kleberg County and URI have entered an agreement concerning restoration at the KVD Mine<sup>192</sup>. URI agreed to pump and treat at least 240 million gallons of groundwater per year until restoration is complete in PAAs 1, 2, and 3<sup>193</sup>. URI also agreed to monitor water levels in a number of monitor wells in PAA-3<sup>194</sup>.

In addition, URI will not ask the State to change the Restoration Range Table contained in the mine's general permit<sup>195</sup> unless<sup>196</sup>:

- 1) URI has made a good faith effort to restore the groundwater. This includes withdrawing and treating at least six pore volumes of water from each production well field.

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<sup>191</sup> URI, 2005d, item 2.

<sup>192</sup> Kleberg County and URI, 2004. The agreement is dated December 3, 2004.

<sup>193</sup> Treatment must be through URI's RO system. Kleberg County and URI, 2004, section 1.4, page 3 of 13.

<sup>194</sup> Kleberg County and URI, 2004, section 1.8, page 5 of 13. The wells are: MW-78, MW-83, MW-85, MW-89, MW-97, MW-102, and MW-125.

<sup>195</sup> TWC, 1990a. This permit covers the entire mine rather than individual PAAs. The Restoration Range Table (Table 2) contains a range of values for each constituent. The upper end of the range for each constituent is greater than the restoration values currently required for each PAA (table 7.2-1). The Restoration Range Table is presented in appendix E.

<sup>196</sup> Kleberg County and URI, 2004, section 1.7, page 4 of 13.

- 2) The concentrations of the constituents used to evaluate water quality have been stable for at least 180 days.
- 3) URI has demonstrated that its operations “*will not result in ground water in wells being made unsuitable for uses to which it was suitable prior to mining, on a per well basis.*” That is, if prior to mining a baseline well met the standards for use as a source of 1) drinking water, 2) livestock water, or 3) irrigation water, it must meet those standards after restoration is completed.
- 4) For PAA-3 and all subsequent PAAs: If, during routine sampling, URI detects a constituent in the production stream that exceeds an EPA primary or secondary drinking water standard, it shall:
  - Monitor for that constituent during restoration.
  - Continue restoration until 1) six pore volumes have been treated, or 2) it has demonstrated that treatment of an additional pore volume will not result in a 5% reduction in the concentration of the constituent.

This requirement will not take effect until production begins in PAA-3.

Finally, URI agreed not to resume mining in PAA-3 until 90% of the PAA-1 production area baseline wells are restored to a condition such that they are suitable for any of the uses that they were suitable for prior to mining, i.e., drinking water, livestock water, or irrigation water<sup>197</sup>.

### **7.3.1 Pump and Treat 240 Million Gallons**

URI has not satisfied this requirement. In 2005 URI treated 235 million gallons of groundwater through its RO system<sup>198</sup>. This is 5 million gallons less than required.

### **7.3.2 Monitor Water Levels**

URI has satisfied this requirement<sup>199</sup>.

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<sup>197</sup> Kleberg County and URI, 2004, section 11.1 (ii), page 10 of 13.

<sup>198</sup> Quarterly RO treatment figures are given in URI, 2005g; URI, 2005i, URI 2005t; and URI 2006b.

<sup>199</sup> Water level data provided by Mark Pelizza of URI, January 2006.

### 7.3.3 Pore Volumes

#### 7.3.3.1 PAA-1

URI has satisfied this requirement by withdrawing and treating more than six pore volumes from each production well field in PAA-1<sup>200</sup>.

#### 7.3.3.2 PAA-2

URI has begun restoration in PAA-2 but has not yet withdrawn six pore volumes<sup>201</sup>.

#### 7.3.3.3 PAA-3

URI has not yet begun restoring PAA-3.

### 7.3.4 Stabilization Monitoring

URI has said different things regarding stabilization monitoring. They have said “URI has not begun *“official” stability sampling in PA1.*”<sup>202</sup> They have also said “... *all sampling that has been conducted subsequent to the completion of active RO treatment may be considered stability sampling.*”<sup>203</sup> This seems to mean that URI believes it has conducted stabilization monitoring in PAA-1 since restoration efforts ended (March 2004).

However, restoration at PAA-1 is not complete (see section 7.2.1). Therefore, the purpose of any current stabilization monitoring is unclear.

### 7.3.5 Suitability for Use

Before it asks the State to change any restoration requirement in the Restoration Range Table, URI must restore water quality in each baseline well to a level such that it is suitable for the same uses that it was suitable for before mining began. The standards that must be met are listed in table 7.3.5-1. It should be noted that

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<sup>200</sup> URI 2005a, response to question 6; and URI, 2006b, *Individual Well Summary*. This does not apply to well field 7, which is in both PAA-1 and PAA-2. To date, approximately five pore volumes have been withdrawn from well field 7. It should also be noted that the pore volume calculations apply to the well field as a whole, and not to individual wells. For example, a total of 127,876,411 gallons has been pumped from well field 2. That’s equivalent to about 6.2 pore volumes. However, the withdrawals are quite uneven. Some portions of the well field have had more than 20 pore volumes withdrawn (e.g., around well 203). Other portions have had less than one pore volume removed (e.g., around well 268) (URI, 2006b).

<sup>201</sup> URI 2005a, response to question 6; and URI, 2006b, *Individual Well Summary*.

<sup>202</sup> Personal communication with Mark Pelizza of URI, January 5, 2006.

<sup>203</sup> URI 2006a, response to question 6.

URI does not sample the baseline wells for all the constituents listed in table 7.3.5-1<sup>204</sup>.

**Table 7.3.5-1**  
**Water Quality Use Limits<sup>205</sup>**

<b>Constituent /Property<sup>206</sup></b>	<b>Drinking Water Limit</b>	<b>Livestock Water Limit</b>	<b>Irrigation Water Limit</b>
Arsenic (mg/L)	0.01	0.2	0.1
Cadmium (mg/L)	0.005	0.05	0.01
Fluoride (mg/L)	4	- <sup>207</sup>	-
Mercury (mg/L)	0.002	0.000005	-
Nitrate (N) (mg/L)	10	-	-
Selenium (mg/L)	0.05	0.005	0.02
Alpha Radiation (pCi/L)	15	15	15
Radium 226 (pCi/L)	5	5	5
Radon-222 (pCi/L)	300	-	-
Uranium (mg/L)	0.03	0.03	0.03
Chloride (mg/L)	250* <sup>208</sup>	-	-
Iron (mg/L)	0.3*	-	-
Manganese (mg/L)	0.05*	-	-
pH <sup>209</sup>	6.5 – 8.5*	6.5 – 8.5	4.5 – 9.0
Molybdenum (mg/L)	-	1.0	-
Sulfate (mg/L)	250	3000	200
TDS (mg/L)	500	5000	2000

<sup>204</sup> URI samples the baseline wells only for the eight constituents listed in tables 7.2.1-1 and 7.2.2-1.

<sup>205</sup> Kleberg County and URI, 2004, page 5 of 13. The sources of the limits are the U.S. EPA primary or secondary drinking water standards, and the State of Wyoming water quality rules.

<sup>206</sup> All units are mg/L except where noted.

<sup>207</sup> Blank indicates no limit given in agreement between Kleberg County and URI.

<sup>208</sup> Asterisks indicate the limit is a secondary drinking water standard rather than a primary standard.

<sup>209</sup> Standard units.

### 7.3.5.1 PAA-1

Prior to mining, URI sampled 16 baseline wells in PAA-1. Only one well, I-11, was suitable for use as a source of drinking, livestock, or irrigation water (table 7.3.5.1-1)<sup>210</sup>.

URI's restoration efforts have not succeeded in returning well I-11 to its pre-mining condition. Uranium is more than 40 times higher than the EPA primary drinking water limit. Molybdenum is higher than the livestock limit. Uranium and molybdenum exceed their pre-mining concentrations by factors of more than 150 and 15, respectively (see table 7.4-1).

URI has stated that it may use reductants or bacteria to restore well I-11<sup>211</sup>. Unfortunately, the effectiveness of the reductants may decline over time<sup>212</sup>. Therefore, long-term monitoring should be required before the restoration is declared to be complete.

Additional discussion of well I-11 is presented in appendix H, responses to comments 12 and 14, and recommendation 7.

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<sup>210</sup> The EPA secondary drinking water limits for chloride and TDS are exceeded. However, these are not health-based limits and would not prevent water from well I-11 from being used for drinking water.

<sup>211</sup> Appendices G and H, comment 14.

<sup>212</sup> See section 7.5.

**Table 7.3.5.1-1  
PAA-1 Baseline Wells  
Pre-mining Water Quality<sup>213</sup>**

<b>Constituent /Property<sup>214</sup></b>	<b>EX-1</b>	<b>EX-2</b>	<b>EX-3</b>	<b>I-1</b>	<b>I-2</b>	<b>I-3</b>	<b>I-4</b>	<b>I-5</b>
Arsenic	0.001	0.003	0.004	0.001	0.003	0.006	0.001	0.003
Cadmium <sup>215</sup>	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<b>0.01</b>
Fluoride	0.6	0.53	0.5	0.54	0.57	0.59	0.49	0.6
Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nitrate (N)	<0.1	<0.1	1.71	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium	0.001	0.006*	0.014*	0.001	0.001	0.002	<0.001	<0.001
Alpha Radiation <sup>216</sup>	NA <sup>217</sup>	NA	NA	NA	NA	NA	NA	NA
Radium 226 <sup>218</sup>	<b>28.0<sup>219</sup></b>	<b>36.2</b>	<b>18.8</b>	<b>13.7</b>	<b>25.0</b>	<b>12.7</b>	<b>47.6</b>	<b>19.2</b>
Radon-222 <sup>220</sup>	NA	NA	NA	NA	NA	NA	NA	NA
Uranium	<b>0.060</b>	<b>0.116</b>	<b>0.927</b>	0.018	<b>0.043</b>	0.021	<b>0.077</b>	<b>0.030</b>
Chloride	233	227	208	216	212	230	230	219
Iron	<0.01	<0.01	0.26	0.07	0.02	0.03	0.05	0.06
Manganese	0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01
pH <sup>221</sup>	8.54* <sup>222</sup>	8.53*	8.28	8.72*	8.66*	8.91*	8.78*	8.8*
Molybdenum	<0.01	<0.01	<0.01	0.14	0.02	0.03	0.06	0.04
Sulfate	199	227	188	200	179	177	239	185
EC <sup>223</sup>	2100	1710	1580	1660	1630	1650	1750	1650
TDS <sup>224</sup>	1000*	1020*	944*	1030*	1020*	975*	1050*	965*

<sup>213</sup> URI 1987a. Pre-mining analyses for these wells are presented in the section titled *Ground water Analysis Reports (All Baseline and Monitor Wells)*. Note – nomenclature for baseline wells is not consistent. For example, EX-1 is also referred to as 1EX. 1I is also referred to as I-1, etc. (compare analytical reports and figure 1 in 1987a).

<sup>214</sup> All units are mg/L except where noted.

<sup>215</sup> The cadmium detection limit (0.01) is higher than the EPA primary drinking water standard (0.005).

<sup>216</sup> Units = pCi/L.

<sup>217</sup> Not analyzed.

<sup>218</sup> Units = pCi/L.

<sup>219</sup> Bold indicates value above EPA Primary Drinking Water Limit (table 7.3.5-1).

<sup>220</sup> Units = pCi/L.

<sup>221</sup> Standard units.

<sup>222</sup> Asterisk indicates value above EPA Secondary Drinking Water Limit, Livestock Limit, or Irrigation Limit (table 7.3.5-1).

<sup>223</sup> EC = electrical conductivity, units =  $\mu$ mhos/cm.

<sup>224</sup> TDS = total dissolved solids.

**Table 7.3.5.1-1 (continued)**  
**PAA-1 Baseline Wells**  
**Pre-mining Water Quality**

<b>Constituent /Property</b>	<b>I-6</b>	<b>I-7</b>	<b>I-8</b>	<b>I-9</b>	<b>I-10</b>	<b>I-11 (161)</b>	<b>I-12 (PBL-4)</b>	<b>I-13</b>
Arsenic	<b>0.02</b>	0.002	0.001	0.002	0.001	0.001	<b>0.022</b>	0.005
Cadmium	<b>0.03</b>	<b>0.01</b>	<b>0.01</b>	<b>0.01</b>	<b>0.01</b>	<0.01	<0.01	<0.01
Fluoride	0.6	0.53	0.51	0.52	0.53	0.63	0.6	0.56
Mercury	<b>0.01</b>	<0.001	<0.001	<0.001	<0.001	0.0002*	<0.0002	<0.001
Nitrate (N)	<0.02	<0.1	<0.1	<0.04	0.35	<0.1	0.5	0.95
Selenium	<b>0.072</b>	0.001	<0.001	0.003	<0.001	<0.001	0.001	0.009*
Alpha Radiation	NA	NA	NA	NA	NA	NA	NA	NA
Radium 226	<b>13</b>	<b>21.6</b>	<b>42.1</b>	<b>43.5</b>	<b>23.1</b>	0.66	0.84	<b>12.1</b>
Radon-222	NA	NA	NA	NA	NA	NA	NA	NA
Uranium	<b>0.68</b>	<b>0.077</b>	<b>0.180</b>	<b>0.13</b>	0.009	0.008	0.016	<b>0.156</b>
Chloride	229	234	229	229	219	352*	242	231
Iron	<0.02	0.03	0.05	0.05	0.02	0.11	<0.01	<0.01
Manganese	<0.001	0.02	0.01	<0.01	<0.01	<0.01	0.03	<0.01
pH	8.58*	8.85*	8.42	8.62*	8.48	7.82	8.71*	8.45
Molybdenum	0.014	0.09	0.05	0.08	<0.01	<0.1	0.2	<0.01
Sulfate	189	235	226	212	199	81	229	179
EC	1710	1740	1730	1670	972	1680	1750	1720
TDS	1030*	1030*	1030*	975*	972*	944*	972*	988*

### 7.3.5.2 PAA-2

Prior to mining, URI sampled five baseline wells in PAA-2. None of them were suitable for use as a source of drinking water, for livestock, or for irrigation (table 7.3.5.2-1).

**Table 7.3.5.2-1  
PAA-2 Baseline Wells  
Pre-mining Water Quality<sup>225</sup>**

<b>Constituent /Property<sup>226</sup></b>	<b>BL-547</b>	<b>BL-1047</b>	<b>BL-1240</b>	<b>BL-1265</b>	<b>BL-1491</b>
Arsenic	0.004	0.005	<b>0.017</b>	<0.001	0.005
Cadmium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Fluoride	0.65	0.60	0.62	0.57	0.60
Mercury	<0.0001	<0.0001	0.0001*	<0.0001	<0.0001
Nitrate (N)	0.36	0.28	0.56	0.09	1.2
Selenium	0.005*	0.017*	0.010*	<0.001	0.008*
Alpha Radiation <sup>227</sup>	NA	NA	NA	NA	NA
Radium 226 <sup>228</sup>	<b>31<sup>229</sup></b>	<b>96</b>	<b>35</b>	<b>139</b>	<b>157</b>
Radon-222 <sup>230</sup>	NA	NA	NA	NA	NA
Uranium	<b>1.20</b>	<b>3.72</b>	<b>0.505</b>	<b>0.254</b>	<b>3.75</b>
Chloride	218	209	228	239	227
Iron	0.03	0.03	0.02	0.02	0.02
Manganese	<0.01	0.01	<0.01	0.01	0.01
pH <sup>231</sup>	8.66* <sup>232</sup>	8.18	8.32	8.38	8.15
Molybdenum	0.29	0.36	0.34	0.05	0.84
Sulfate	213	206	239	237	225
EC <sup>233</sup>	1590	1610	1720	1720	1670
TDS <sup>234</sup>	976*	1010*	1070*	1060*	1060*

<sup>225</sup> URI 1989a. Pre-mining analyses for these wells are presented in the section titled *Ground water Analysis Reports (All Baseline and Monitor Wells)*.

<sup>226</sup> All units are mg/L except where noted.

<sup>227</sup> Units = pCi/L.

<sup>228</sup> Units = pCi/L.

<sup>229</sup> Bold indicates value above EPA Primary Drinking Water Limit (table 7.3.5-1).

<sup>230</sup> Units = pCi/L.

<sup>231</sup> Standard units.

<sup>232</sup> Asterisk indicates value above EPA Secondary Drinking Water Limit, Livestock Limit, or Irrigation Limit (table 7.3.5-1).

<sup>233</sup> EC = electrical conductivity, units =  $\mu$ mhos/cm.

<sup>234</sup> TDS = total dissolved solids.

### 7.3.5.3 PAA-3

Prior to mining, URI sampled 27 baseline wells in PAA-3. None of them were suitable for use as a source of drinking water, for livestock, or for irrigation (table 7.3.5.3-1).

**Table 7.3.5.3-1  
PAA-3 Baseline Wells  
Pre-mining Water Quality<sup>235</sup>**

<b>Constituent /Property<sup>236</sup></b>	<b>BL-8501</b>	<b>BL-8502</b>	<b>BL-8503</b>	<b>BL-8504</b>	<b>BL-8505</b>	<b>BL-8506</b>
Arsenic	<b>0.017</b> <sup>237</sup>	0.004	0.006	0.008	0.005	0.003
Cadmium <sup>238</sup>	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Fluoride	0.64	0.77	0.80	0.74	0.69	0.56
Mercury	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nitrate (N)	<0.01	<0.01	<0.01	<0.01	<0.01	2.1
Selenium	0.004	<0.001	0.004	<b>0.051</b>	0.016*	<b>0.063</b>
Alpha Radiation <sup>239</sup>	Na	NA	NA	NA	NA	NA
Radium 226 <sup>240</sup>	<b>6.2</b>	1.9	4.4	<b>14</b>	3.4	<b>5.3</b>
Radon-222 <sup>241</sup>	NA	NA	NA	NA	NA	NA
Uranium	<b>0.152</b>	<b>0.032</b>	<b>0.101</b>	<b>0.101</b>	<b>0.047</b>	<b>0.041</b>
Chloride	216	362*	290*	335*	319*	224
Iron	<0.01	<0.01	0.04	0.02	0.04	0.01
Manganese	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
pH <sup>242</sup>	8.89* <sup>243</sup>	8.01	9.08*	8.45	9.19*	7.69
Molybdenum	0.07	0.23	0.39	1.2*	3.2*	0.02
Sulfate	211	478*	337*	487*	358*	183
EC <sup>244</sup>	1590	2390	1970	2310	2060	1590
TDS <sup>245</sup>	929*	1440*	1180*	1420*	1210*	904*

<sup>235</sup> URI, 1997a, pre-mining analyses for these wells are presented in the section titled *Ground water Analysis Report*.

<sup>236</sup> All units are mg/L except where noted.

<sup>237</sup> Bold indicates value above EPA Primary Drinking Water Limit (table 7.3.5-1).

<sup>238</sup> The cadmium detection limit (0.01) is higher than the EPA primary drinking water standard (0.005).

<sup>239</sup> Units = pCi/L.

<sup>240</sup> Units = pCi/L.

<sup>241</sup> Units = pCi/L.

<sup>242</sup> Standard units.

<sup>243</sup> Asterisk indicates value above EPA Secondary Drinking Water Limit, Livestock Limit, or Irrigation Limit (table 7.3.5-1).

<sup>244</sup> EC = electrical conductivity, units =  $\mu$ mhos/cm.

<sup>245</sup> TDS = total dissolved solids.

**Table 7.3.5.3-1 (continued)**  
**PAA-3 Baseline Wells**  
**Pre-mining Water Quality**

<b>Constituent /Property</b>	<b>BL-8507</b>	<b>BL-8508</b>	<b>BL-8509</b>	<b>BL-8510 (5/28/97)</b>	<b>BL-8510<sup>246</sup> (6/18/97)</b>	<b>BL-8511</b>
Arsenic	0.009	0.008	0.003	<b>0.010</b>	0.006	<b>0.025</b>
Cadmium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001
Fluoride	0.56	0.59	0.59	0.97	0.56	0.49
Mercury	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nitrate (N)	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
Selenium	0.008*	<0.001	<0.001	0.004	<0.001	0.004
Alpha Radiation	NA	NA	NA	NA	NA	NA
Radium 226	<b>9.6</b>	4.2	0.3	3.2	3.3	4.3
Radon-222	NA	NA	NA	NA	NA	NA
Uranium	<b>0.194</b>	<b>0.229</b>	<b>0.084</b>	<b>0.101</b>	<b>0.094</b>	<b>0.049</b>
Chloride	282*	290*	279*	138	293*	293*
Iron	<0.01	0.01	0.02	0.01	<0.01	<0.01
Manganese	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
pH	9.03*	9.07*	9.57*	8.29	8.41	8.26
Molybdenum	0.05	0.11	0.06	0.11	0.07	0.02
Sulfate	364*	366*	370*	228	392*	453*
EC	1970	1950	2010	1120	1960	2140
TDS	1180*	1170*	1180*	677*	1170*	1290*

**Table 7.3.5.3-1 (continued)**  
**PAA-3 Baseline Wells**  
**Pre-mining Water Quality**

<b>Constituent /Property</b>	9101	9103	9105	9107	9109	9111
Radium 226	<b>26</b>	<b>12</b>	<b>49</b>	<b>35</b>	<b>46</b>	<b>30</b>
Uranium	<b>0.372</b>	<b>0.131</b>	<b>0.391</b>	<b>0.543</b>	<b>1.50</b>	<b>0.172</b>
pH	9.08	8.71	8.39	8.73	9.60	9.11
Molybdenum	0.25	0.14	0.05	0.25	0.11	0.05
EC	1650	1610	1570	1780	1800	1600

<sup>246</sup> URI, 1997a contains two pre-mining analyses for BL-8510, one dated 5/28/97 and one dated 6/18/97.

**Table 7.3.5.3-1 (continued)  
PAA-3 Baseline Wells  
Pre-mining Water Quality**

<b>Constituent /Property</b>	9113	9302	9304	9306	9308 (4/22/98)	9308 (6/8/98)
Radium 226	<b>34</b>	<b>40</b>	<b>78</b>	<b>51</b>	<b>17</b>	<b>94</b>
Uranium	<b>0.421</b>	<b>0.064</b>	<b>0.644</b>	<b>1.54</b>	<b>0.899</b>	<b>0.787</b>
pH	8.78	8.45	8.07	8.63	8.49	8.11
Molybdenum	0.13	0.06	0.02	0.06	0.40	0.04
EC	2160	1580	1550	1550	1880	1570

**Table 7.3.5.3-1 (concluded)  
PAA-3 Baseline Wells  
Pre-mining Water Quality**

<b>Constituent /Property</b>	9310 (4/22/98)	9310 (6/8/98)	9312	9314	9315	9602
Radium 226	<b>44</b>	<b>57</b>	<b>33</b>	<b>11</b>	<b>11</b>	<b>9.8</b>
Uranium	<b>0.224</b>	<b>1.03</b>	<b>0.356</b>	<b>0.186</b>	<b>0.293</b>	<b>0.270</b>
pH	7.68	8.57	8.98	8.70	8.95	8.39
Molybdenum	1.6	0.29	0.15	0.07	0.02	0.15
EC	2820	1740	1670	1780	1720	1740

### **7.3.6 Ninety Percent of PAA-1 Baseline Wells Restored**

This requirement has not been satisfied. The only baseline well in PAA-1 that was suitable for any use before mining began (I-11) is no longer suitable for any of those uses.

### **7.3.7 County Restoration Requirements, Conclusion**

Of the 48 baseline wells sampled by URI, only one was suitable for any use before mining began (I-11, PAA-1). Mining degraded the quality of water produced by this well and restoration has not been effective. Well I-11 is no longer suitable for use as a source of drinking water, for livestock, or for irrigation. Under its agreement with the County, URI will not ask the State to change any restoration requirement in the Restoration Range Table, nor will it resume mining in PAA-3, until well I-11 is restored.

Of the other requirements agreed to by the County and URI, URI satisfied the requirements to monitor water levels in PAA-3 and to withdraw at least six pore-volumes from PAA-1. However, URI did not satisfy the requirement to pump and treat at least 240 million gallons at the KVD Mine.



#### 7.4 Restoration to Pre-mining Quality

URI is not required to restore water quality to the conditions that existed prior to mining. URI is only required to satisfy the State restoration requirements and its agreement with Kleberg County. Nonetheless, the effects that the KVD Mine has had on water quality are of interest and are examined in this section.

Mining has resulted in the deterioration of water quality with respect to constituents associated with the uranium ore. As shown in figures 4.2-1 through 4.2-3, and table 7.4-1<sup>247</sup> average levels of sulfate, uranium, and molybdenum are higher than they were before mining began.

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<sup>247</sup> Post-mining data in the table are from the last available analysis, URI, 2006e. There are some discrepancies in this document between the values listed in table 1 and the values given on the sheets for each well. According to URI, the values on the sheets for each well are correct (personal communication, Ron Grant of URI, June 20, 2006).

**Table 7.4-1  
Comparison of Pre-mining and Post-mining Water Quality  
PAA-1 and PAA-2 Baseline Wells**

Well ID	Sulfate (mg/L)		Uranium (mg/L) <sup>248</sup>		Molybdenum (mg/L) <sup>249</sup>	
	Pre-mine	Post-mine	Pre-mine	Post-mine	Pre-mine	Post-mine
EX-2	227	655	0.116	1.53	<0.01	0.01
EX-3	188	165	0.927	1.78	<0.01	0.06
I-1	200	632	0.018	0.509	0.14	1.50
I-2	179	154	0.043	0.093	0.02	0.01
I-3	177	361	0.021	2.63	0.03	0.04
I-4	239	297	0.077	0.0	0.06	1.60
I-5	185	269	0.030	2.04	0.04	2.10
I-6	189	69	0.68	0.085	0.014	0.04
I-7	235	354	0.077	0.085	0.09	3.80
I-8	226	142	0.180	0.636	0.05	1.00
I-9	212	422	0.13	0.932	0.08	2.60
I-10	199	136	0.009	0.195	<0.01	3.50
I-11	81	226	0.008	1.27	<0.01	1.60
I-12	229	495	0.016	0.0	0.2	2.20
I-13	179	127	0.156	2.63	<0.01	0.55
PAA-1 Average	196	300	0.166	0.961	0.05	1.37
BL-547 <sup>250</sup>	213	1447	1.2	9.50	0.29	1.86
BL-1047 <sup>251</sup>	206	394	3.72	0.170	0.36	0.05
BL-1240	239	301	0.505	0.170	0.34	0.63
BL-1265	237	204	0.254	1.27	0.05	0.12
BL-1491	225	226	3.75	2.63	0.84	0.26
PAA-2 Average	224	514	1.89	2.75	0.38	0.58

Figures 7.4-1 through 7.4-5 illustrate the effects of mining on uranium in individual wells<sup>252</sup>. The uranium in some wells appears to be cleaning up well. An example of this is well I-7 (figure 7.4-1). Restoration has resulted in the rapid decline of uranium concentrations. Concentrations have remained near the pre-mining level since the beginning of 2002.

<sup>248</sup> Post-mine results multiplied by 0.848 to convert U3O8 to U.

<sup>249</sup> In cases where the concentration is below the detection limit, a value of one-half the detection limit is used to calculate the average.

<sup>250</sup> Post-mining data for BL-547 provided by Ron Grant of URI, June 21, 2006. All data for post-mining sample collected on 5/31/06, except for the molybdenum sample. The molybdenum value is for a sample collected on 2/9/06.

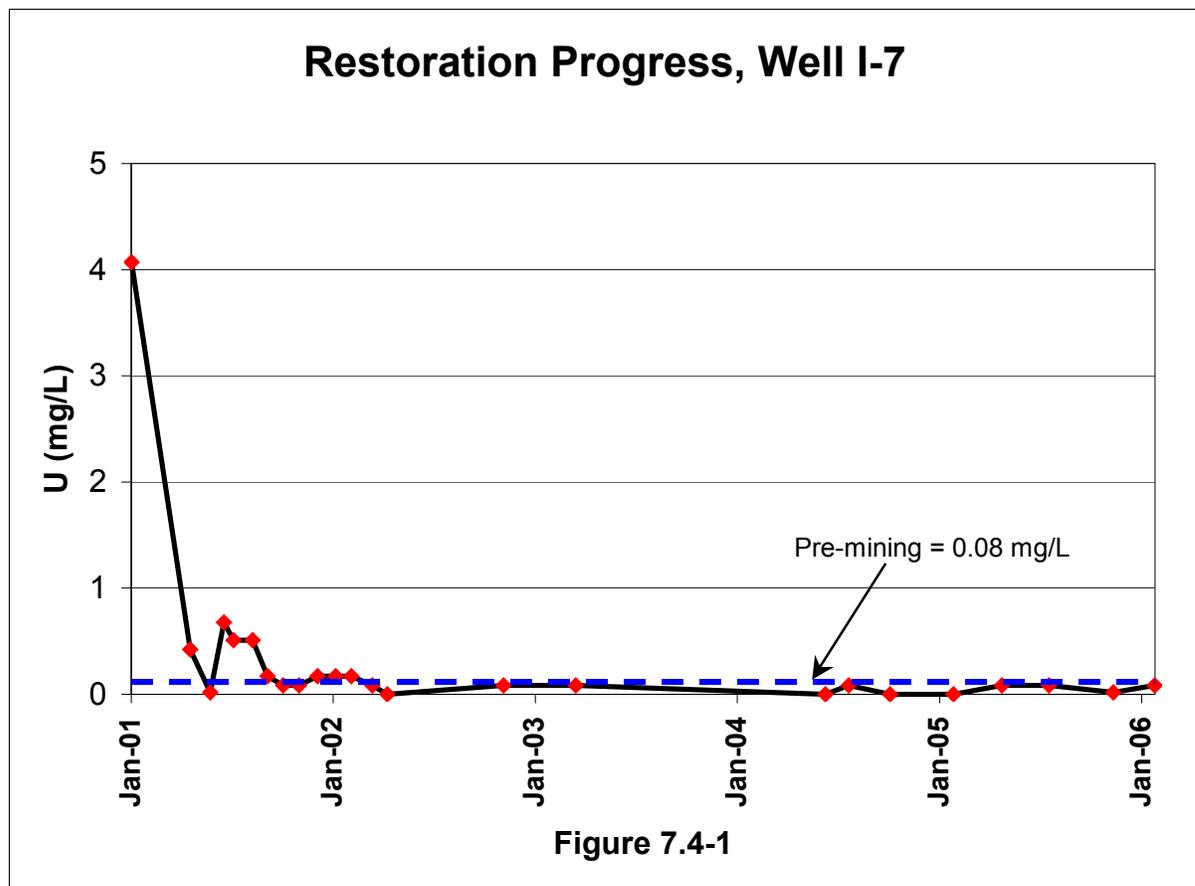
<sup>251</sup> First samples collected since 8/9/04.

<sup>252</sup> Post-mine results multiplied by 0.848 to convert U3O8 to U.

On the other hand, uranium concentrations in some wells remain quite high. This can be seen in wells EX-3, I-3, I-11, and BI-547 (figures 7.4-2 - 7.4-5).

In some wells, uranium concentrations rapidly declined after restoration began, but began to rise again as restoration continued (well I-13, figure 7.4-6).

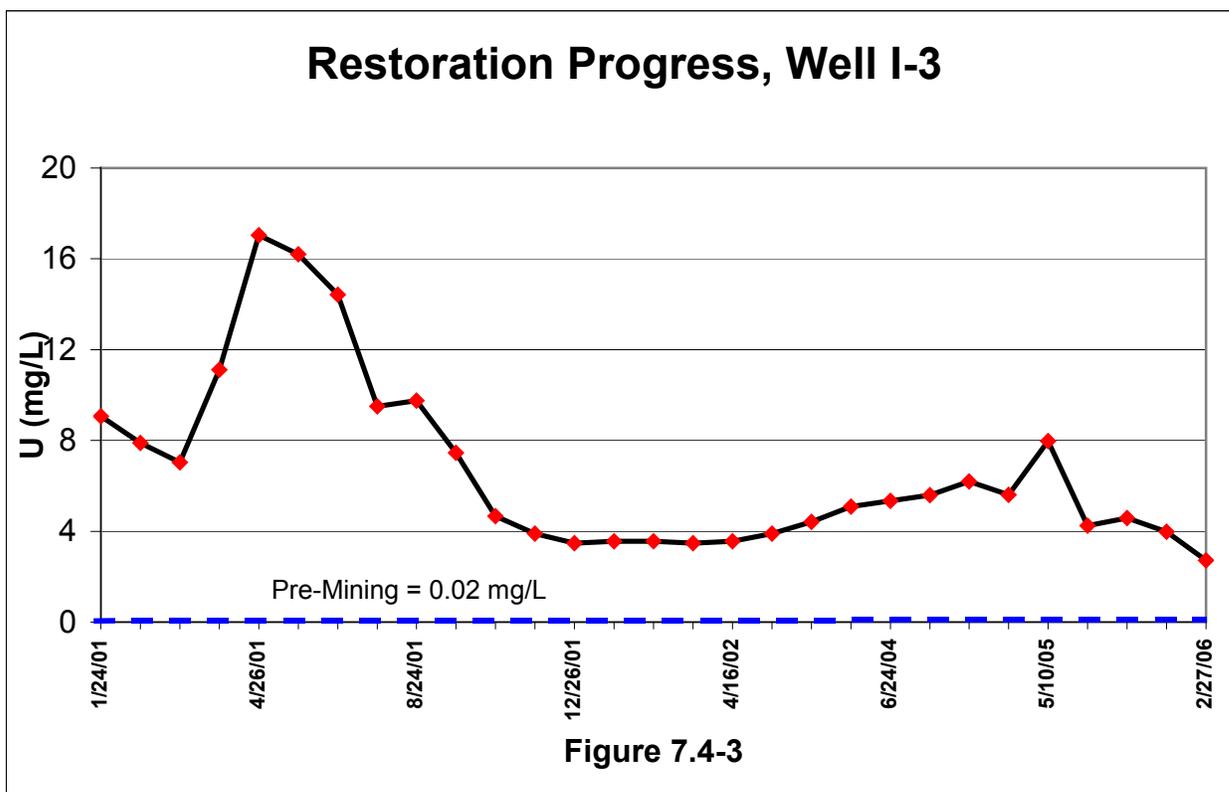
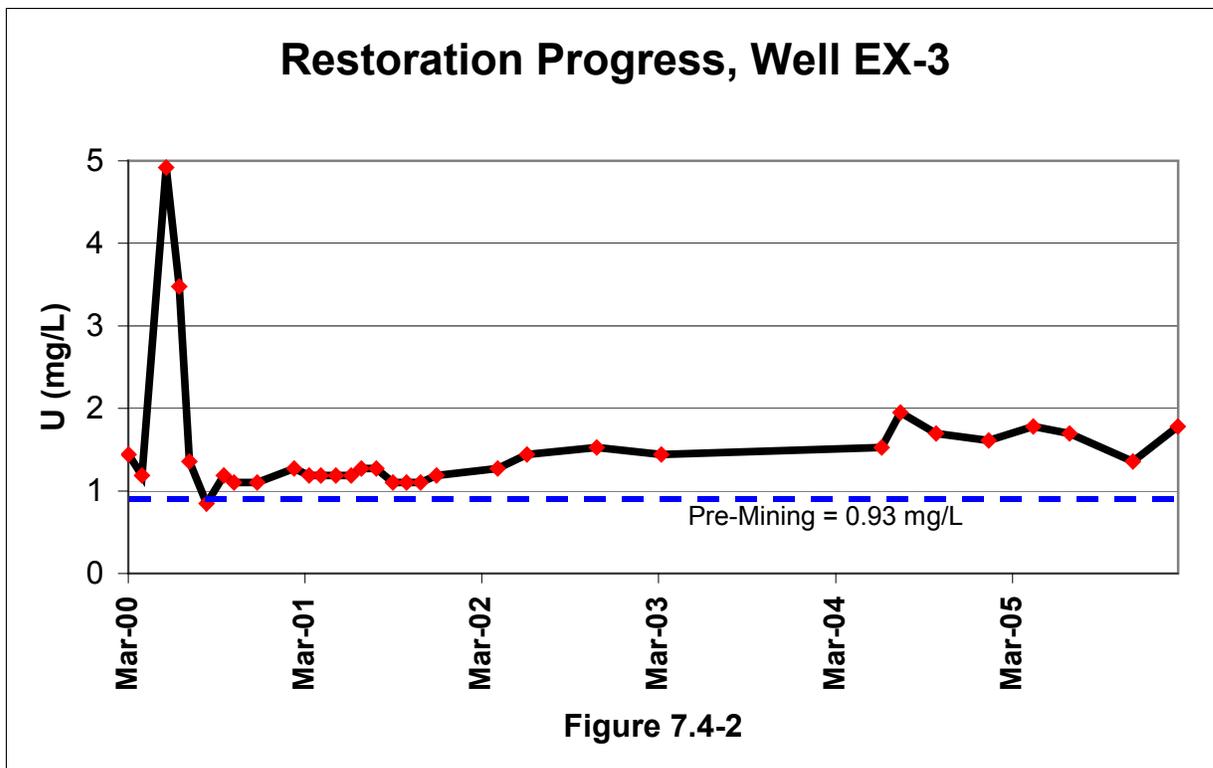
The 2006 uranium concentrations in well BL-547 should be noted (figure 7.4-5). Until 2006, the uranium concentrations in BL-547 remained fairly constant at 20 mg/L to 30 mg/L. Then, URI's in-house laboratory reported a value of 1.4 mg/L for a sample collected on 2/9/06<sup>253</sup>. However, a few days later (2/13/06) the CRB and URI split samples from well BL-547. The uranium results reported by two outside laboratories were 35.2 mg/L and 33.0 mg/L<sup>254</sup>. Then, URI's in-house laboratory reported a uranium concentration of 11.2 mg/L for a sample collected on 5/31/06<sup>255</sup>.

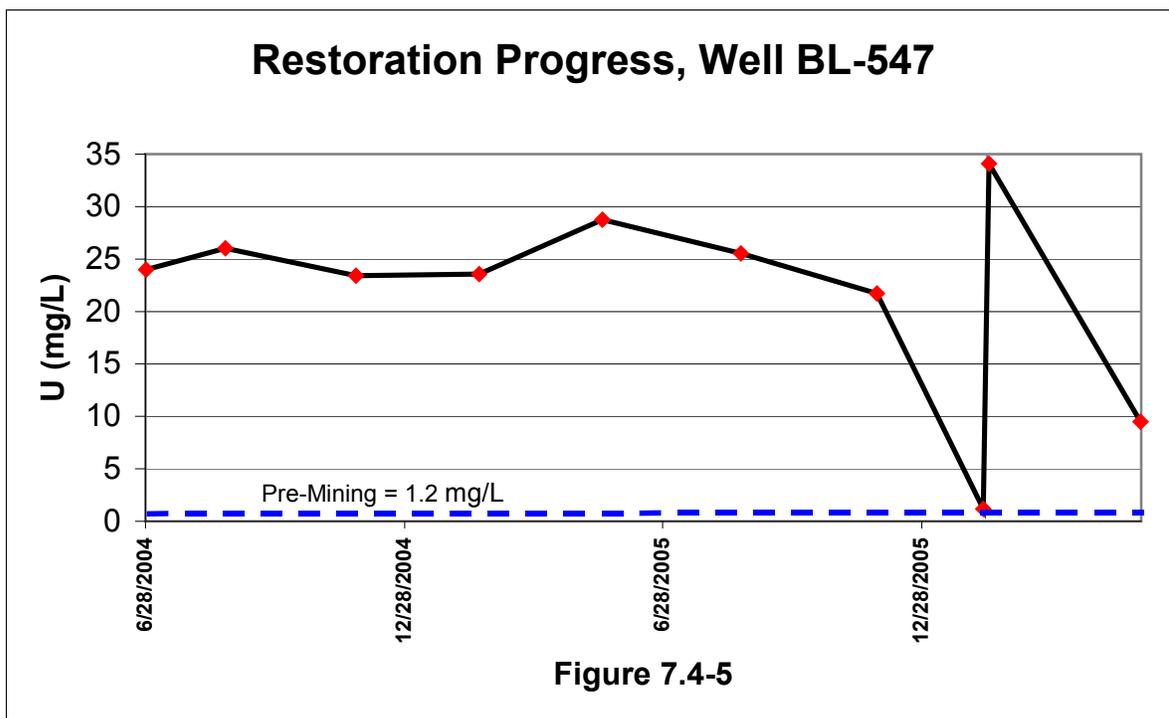
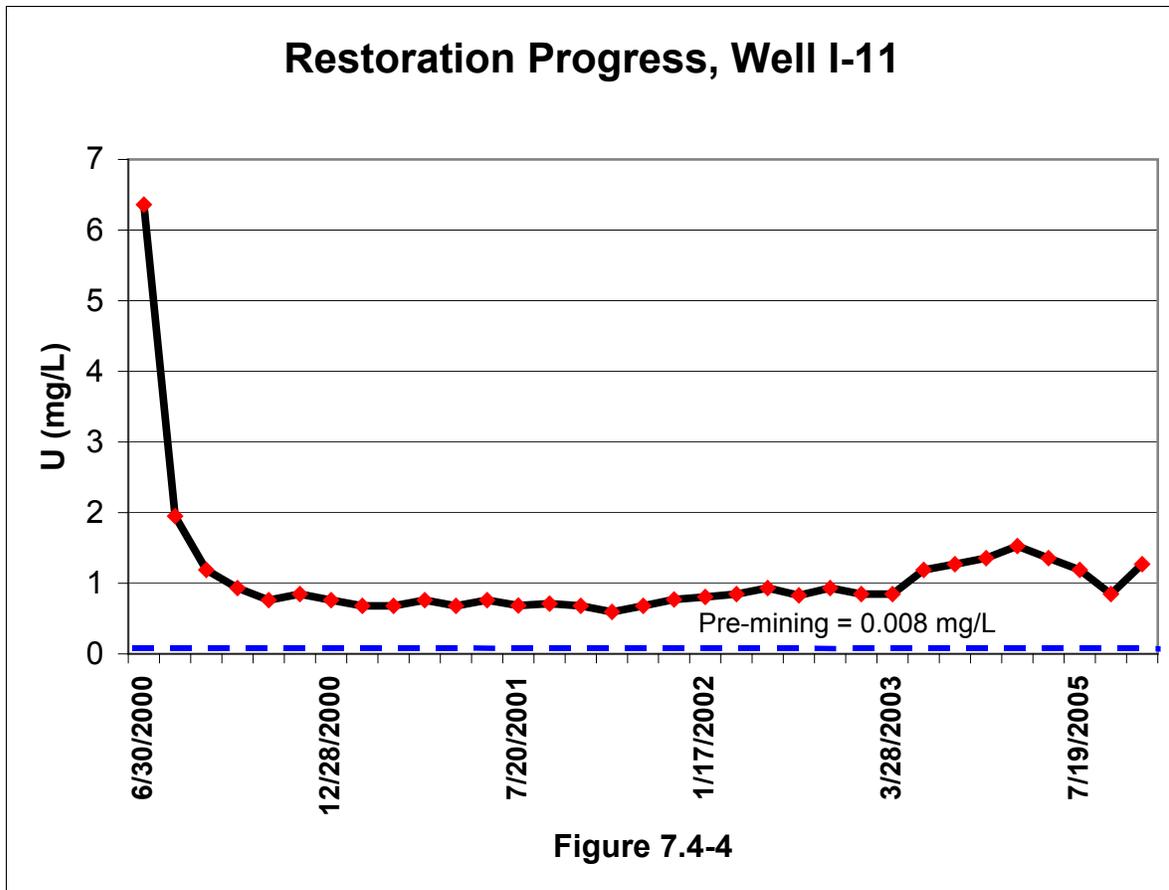


<sup>253</sup> URI, 2006e.

<sup>254</sup> See appendix F. The value plotted in figure 7.4-5 is the average of the two values reported by the outside laboratories.

<sup>255</sup> See appendix B for a discussion of URI's in-house uranium analyses.







other hand, some groundwater travels relatively rapidly (> 100 ft/yr). This could adversely affect nearby wells in a decade or less.

It might be argued that the post-restoration migration of mining solutions won't be a problem. This is based on the premise that the oxidizing conditions created by mining (see section 3.2) are temporary. After mining and restoration ceases, the natural reducing conditions will be re-established. Reducing conditions will result in the precipitation (removal) of uranium and other constituents associated with the ore<sup>256</sup>. In addition, other attenuation mechanisms such as dispersion and sorption (geochemical attenuation) will act to decrease contaminant concentrations<sup>257</sup>.

However, there is no guarantee that reducing conditions will be quickly re-established, or even that they will be re-established at all<sup>258</sup>. There is little if any indication that reducing conditions are being re-established at the KVD mine<sup>259</sup>. Although it has been more than five years since mining ceased in PAAs 1 and 2, concentrations of uranium, molybdenum, and sulfate remain well above their baseline levels<sup>260</sup>. Radium-226 concentrations also remain elevated<sup>261</sup>.

There have been attempts to artificially restore reducing conditions at some in-situ uranium mines. However, the artificially restored reducing conditions may not persist for long periods of time<sup>262</sup>.

URI's statements regarding the re-establishment of reducing conditions and the effectiveness of dispersion and sorption are not based on data from the KVD Mine<sup>263</sup>. URI has not performed a thorough investigation of these factors at the KVD Mine<sup>264</sup>. URI has proposed investigating these factors in the future<sup>265</sup>.

If post-restoration concentrations remain above baseline levels and EPA drinking water standards, URI should be required to establish a long term monitoring

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<sup>256</sup> NRC, 1983, page 31.

<sup>257</sup> Appendices G and H, comment 16; and Demuth and Schramke, 2006, pages iii and 36.

<sup>258</sup> NRC, 2005, page 17.

<sup>259</sup> URI has measured the oxidation/reduction potential of groundwater at the KVD Mine, but records of the measurements were discarded (Mike Maxson of URI, December 2005).

<sup>260</sup> See table 7.4-1.

<sup>261</sup> Compare values in tables 7.3.5.1-1 and 7.3.5.2-1 with the values in appendix F. The re-establishment of reducing conditions will not decrease radium-226 concentrations (Demuth and Schramke, 2006, pages ii and 32).

<sup>262</sup> At the Ruth, Wyoming in-situ uranium mine, hydrogen sulfide was injected into the production zone to restore reducing conditions. Subsequent monitoring indicated that oxidizing conditions began to reappear in less than a year (NRC, 2005, pages 17 and 18).

<sup>263</sup> Appendices G and H, comments 2 and 16.

<sup>264</sup> Although URI has measured the oxidation/reduction potential of groundwater at the KVD Mine, records of the measurements were not kept (Mike Maxson of URI, December 2005).

<sup>265</sup> Appendix G, recommendations for additional work; and Demuth and Schramke, 2006, pages 41 and 42.

program, and if necessary, restoration program at the mine. These programs should be designed in cooperation with the CRB.

How long should long-term monitoring be conducted? According to URI, the portion of the aquifer that was oxidized as a result of mining will eventually return to its original, reduced state<sup>266</sup>. As a result, redox-sensitive metals<sup>267</sup> such as uranium will be precipitated<sup>268</sup>. Thus, it seems reasonable to continue monitoring until redox conditions are permanently re-established and contaminant concentrations return to their pre-mining levels.

The issue of post-restoration contamination is also discussed in appendix H, responses to comments 2, and 16.

## 8.0 Conclusions

The major conclusions reached in this report are summarized below.

1. Pre-mining groundwater flow rates at the KVD Mine ranged from about 1 ft/yr to 350 ft/yr. Flow rates would be even higher during mining due to the steep hydraulic gradients produced by injection and extraction wells (section 2.1 and appendix A).
2. The pre-mining quality of groundwater at the KVD Mine was poor. Concentrations of several parameters (e.g., uranium, radium-226, TDS) exceeded EPA primary or secondary drinking water standards (section 4.1).
3. Mining caused a further deterioration in water quality. During mining concentrations of uranium, molybdenum, bicarbonate, calcium, chloride, sulfate, and EC were significantly higher than pre-mining concentrations (section 4.2).
4. Some of the analytical results for uranium are unreliable. The lower the concentration, the less reliable the results (appendix B).
5. URI has not conducted a thorough investigation of the factors that influence groundwater flow rates at the KVD Mine. A thorough investigation would include additional aquifer tests, and measurements of local and regional hydraulic gradients (appendices A and H, response to comment 4).

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<sup>266</sup> URI, 2006f, comments 2 and 16; and Demuth and Schramke, 2006, page iii.

<sup>267</sup> Redox sensitive constituents are those that are affected by changes in the oxidation-reduction potential of the groundwater. They include uranium, molybdenum, and sulfate.

<sup>268</sup> URI, 2006f, comments 2, 15, and 16. Also, Demuth and Schramke, 2006, pages iii and 41.

6. URI employs sampling and sample preservation techniques that may alter the composition of groundwater samples that it collects (section 4.3).
7. The State's method of determining whether an excursion has occurred is biased against declaring excursions. The parameter values used to define excursions (control parameter upper limits) are arbitrary and subject to domination by unusual parameter values (section 5.1).
8. The monitor wells that are supposed to detect excursions are ill suited to that purpose. Mining solutions that reach them are subject to dilution as they are sampled. A series of nested wells with shorter screen lengths would be more likely to detect excursions (section 5.1).
9. Use of UTLs for EC data indicates that excursions have occurred at 15 monitor wells, rather than just the two wells acknowledged by URI (section 5.2).
10. There is no reason to believe that any domestic well has been affected by mining solutions emanating from the KVD Mine (section 6).
11. The State's restoration requirements may apply to relatively few baseline wells in each PAA. Restoring the baseline wells to State standards will not guarantee that all areas of a PAA have been properly restored (section 7.1).
12. Some of URI's 'supplementary baseline wells' were not sampled until after uranium production began. Thus, the initial samples collected from these wells may not represent pre-mining conditions. In addition, the 'baseline' analyses for some supplementary wells are inconsistent (section 7.1.1).
13. Groundwater restoration efforts in PAAs 1 and 2 have failed to meet the requirements of the State of Texas. In PAA-1 uranium, chloride, calcium, bicarbonate, sulfate, molybdenum, and EC levels remain higher than the restoration requirements. In PAA-2 uranium, calcium, chloride, bicarbonate, sulfate, molybdenum, pH, and EC levels fail to meet the restoration requirements (section 7.2).
14. URI will probably ask the State to relax the restoration requirements. If the State relaxes the requirements to levels that equal the upper values in the Restoration Range Table, PAA-1 would fail to meet the relaxed requirements for calcium, molybdenum, and pH. PAA-2 would fail to meet the relaxed requirements for uranium, chloride, calcium, sulfate, pH, and EC (section 7.2).
15. The 'baseline' wells for the re-mined area are in areas that have already been mined. Therefore, it is possible that samples collected from these

- wells have been affected by mining solutions from past operations (section 7.2).
16. In its agreement with Kleberg County, URI is required to pump and treat at least 240 million gallons of groundwater per year. URI did not satisfy this requirement in 2005 (section 7.3.1).
  17. In its agreement with Kleberg County, URI agreed that it would not ask the State to change the Restoration Range Table until it restored water quality in each baseline well to a level such that it is suitable for the same uses (drinking, livestock, irrigation) that it was suitable for before mining began. Of 48 baseline wells, only one well, I-11, was suitable for any of the uses before mining began. As a result of mining, this one well is no longer suitable for use as a source of drinking, livestock, or irrigation water (section 7.3.5).
  18. In its agreement with Kleberg County, URI agreed not to resume mining in PAA-3 until 90% of the PAA-1 production area baseline wells are restored to a condition such that they are suitable for any of the uses that they were suitable for prior to mining. This requirement has not been satisfied (section 7.3.6).
  19. Restoration has succeeded in restoring some constituents in some baseline wells to their pre-mining levels. However, in most baseline wells, concentrations of constituents associated with the ore (e.g., uranium, molybdenum) remain well above their pre-mining levels (section 7.4).
  20. URI claims that dispersion, sorption (geochemical attenuation), and the re-establishment of reducing conditions will limit the post-restoration migration of contaminants from the KVD Mine. However, URI has not performed a thorough investigation of dispersion, sorption, or reducing conditions at the KVD Mine (section 7.5).
  21. If restoration does not remove all mining-contaminated groundwater, this groundwater could migrate beyond the mine boundaries after pre-mining hydraulic gradients are reestablished (section 7.5).

## **9.0 Recommendations**

The following recommendations are based on the conclusions reached in this report.

1. URI should sample its wells in a way that is less likely to affect the composition of the samples (e.g., dedicated bailers or pumps). URI should also filter and preserve samples immediately after they are removed from the well (section 4.3, appendix H, response to recommendation 2).

2. URI should conduct additional aquifer tests, and measurements of local and regional hydraulic gradients (appendices A and H, response to comment 4). These tests and measurements should be done in cooperation with the CRB.
3. The State should define excursions in a less arbitrary and biased manner. A standard statistical technique, calculation of upper tolerance limits (UTLs), may be used to define excursions (sections 5.1 and 5.2).
4. State restoration requirements should be applied to all production wells in a PAA, not just to the baseline wells (section 7.1).
5. If URI proposes to use data from any of the 'supplementary baseline wells', they should be required to show that the use of the data is appropriate. This showing should be required for the data from each well that URI proposes to use (section 7.1.1, and appendix H, response to comment 10).
6. The restoration requirements for each PAA should be applied to the remaining wells in each PAA (section 7.2).
7. URI has stated that it may use reductants or bacteria to restore well I-11<sup>269</sup>. However, the effectiveness of the reductants may decline over time<sup>270</sup>. Therefore, long-term monitoring should be required before the restoration is declared to be complete (section 7.3.5.1, appendix H, response to comment 14 and recommendation 7).
8. URI has stated that it may conduct field and modeling studies to investigate the factors that will control the post-restoration migration of contaminants from the KVD Mine<sup>271</sup>. These studies would be useful and should be done in cooperation with the CRB. However, they would not eliminate the need for long-term monitoring (appendix H, URI recommendations).
9. If post-restoration concentrations remain above baseline levels and EPA drinking water standards, URI should be required to establish a long term monitoring, and if necessary, restoration program. Monitoring should continue until reducing conditions are permanently re-established and contaminant concentrations return to their pre-mining levels (Section 7.5).

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<sup>269</sup> Appendices G and H, comment 14.

<sup>270</sup> See section 7.5.

<sup>271</sup> Appendices G and H, recommendations.

## References

Barcelona, M., A. Wehrmann, J.F. Keely, and W.A. Pettyjohn, 1990, *Contamination of Groundwater, prevention, Assessment, Restoration*, Noyes data Corporation.

Demuth, H., and J. Schramke, 2006, *Fate and Transport of Post-Restoration Groundwater Constituents at In-Situ Uranium Leach Facilities*, prepared for Uranium Resources Inc., May 10, 2006.

EPA, 1989, *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities*, April 1989.

EPA, 2002, *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*, EPA 542-S-02-001, May 2002.

EPA, 2004, *2004 Edition of the Drinking Water Standards and Health Advisories*, EPA 822-R-04-005, Winter 2004.

EPA, 2005, Website, URL: <http://www.epa.gov/safewater/standard/setting.html>, updated on February 14th, 2005

Freeze, R.A., J.A. Cherry, 1979, *Groundwater*, Prentice-Hall, Inc., Englewood Cliffs, NJ.

Kleberg County and URI, 2004, *Settlement Agreement Between Kleberg County and URI, Inc.*, December 3rd, 2004.

Nuclear Regulatory Commission (NRC), 1983, *Aquifer Restoration at In-Situ Leach Uranium Mines: Evidence for Natural Restoration Processes*, NUREG/CR-3136, PNL-4604, RU, April 1983.

U.S. Nuclear Regulatory Commission (NRC), 2003, *Standard Review Plan for In Situ Leach Uranium Extraction License Applications, Final Report*, June 2003, NUREG-1569.

NRC, 2005, *Consideration of Geochemical Issues in Groundwater Restoration at Uranium In-Situ Leach Mining Facilities*, Draft Report for Comment, NUREG/CR-6870, June 2005.

Texas Bureau of Radiation Control (TBRC), 1985, *Environmental Assessment, Safety Evaluation Report, and Proposed License Conditions Related to the Uranium Resources Inc. Kingsville Dome Project, Kleberg County, Texas*, July 16, 1985.

Texas Commission on Environmental Quality (TCEQ), 2005a, Transcript of Hearing, TCEQ DOCKET NOS. 1997-1063-UIC AND 2004-0746-UIC, Vol. 5 of 5, August 5, 2005.

TCEQ, 2006a, *Authorization to Conduct Underground Injection Under Provisions of Permit No. URO2827-001, Production Area Authorization 3, Mine: Kingsville Dome, Production Area: URO2827-031*, May 4, 2006.

TBRC, 1988, *Environmental Assessment Related to the Expansion of the URI, Inc. Kingsville Dome Project, Kleberg County, Texas*, License NO. LO 3653, TBRC EA-14-1S, December 30, 1988.

Texas Water Commission (TWC), 1988a, *Permit to Conduct Underground Injection Under Provisions of Permit No. URO 2827, Production Area Authorization, Mine: Kingsville Dome Mining Project, Production Area: URO2827-011*, April 12, 1988.

TWC, 1988b, *Permit No. WDW-248, Permit to Conduct Class I Underground Injection Under Provisions of Chapter 26 & 27, Texas Water Code*, June 21, 1988.

TWC, 1990a, *Permit NO. URO2827, Kingsville Dome Mining Project, Permit to Conduct Underground Injection Under Provisions of Chapters 26 & 27, Texas Water Code*, January 11, 1990. This permit supercedes the permit issued on December 30, 1986.

TWC, 1990b, *Authorization to Conduct Underground Injection Under Provisions of Permit No. URO2827-001, Production Area Authorization, Mine: Kingsville Dome, Production Area: URO2827-021*, June 28<sup>th</sup>, 1990.

TWC, 1998, *Authorization to Conduct Underground Injection Under Provisions of Permit No. URO2827-001, Production Area Authorization 3, Mine: Kingsville Dome, Production Area: URO2827-031*, February 6, 1998. Note: This PAA was voided by the courts. A revised PAA3 is pending (URI, 2005k).

URI, 1983(?), Informal report of 1983 pump test in PAA-1, undated.

URI, 1987a, *Application for Production Area Authorization, PAA-1*, November 27, 1987.

URI, 1989a, *Application for Production Area Authorization 2*, July 7, 1989.

URI, 1997a, *Application for Production Area Authorization URO2827-031, (PAA-3)* June 25, 1997, revised April 9, 2002.

URI, 1997b, *Application for Production Area Authorization URO2827-031, Additional Hydrologic Test Results and Interpretation*, July 23, 1997.

URI, 1998a, *Memo from URI to TNRCC informing the Executive Director that restoration has commenced in PAA-1*, June 8, 1998.

URI, 1999, *Kingsville Dome and Rosita Projects, License L03653, Updated Closure Plan as of 6-1-99*.

URI, 2003a, *Groundwater Sampling Protocol, SOP104*, October 30, 2003.

URI, 2004, *Texas Uranium Project, Environmental Report 2.0*, August 20, 2004.

URI, 2005a, *Memorandum from Mark Pelizza to George Rice*, September 27, 2005.

URI, 2005b, *Records of Injection and Extraction at the Kingsville Dome Mine*, Excel spreadsheet from Mark Pelizza, October 2005.

URI, 2005c, *Map Showing Locations of Production Wells at PAA-2, Kingsville Dome Mine*, from Mark Pelizza, October 2005.

URI, 2005d, *Memorandum from Mark Pelizza to George Rice*, November 9, 2005.

URI, 2005e, *Baseline Uranium and Radium Analyses for the Kingsville Dome Mine*, Excel spreadsheet from Mark Pelizza, October 2005.

URI, 2005f, *Memorandum from Mark Pelizza to George Rice*, November 8, 2005.

URI, 2005g, *Progress Report for Restoration Activities at URI's Kingsville Dome and Rosita Uranium Facilities in South Texas*, July 15, 2005.

URI, 2005h, *Memorandum from Mark Pelizza to George Rice*, November 14, 2005.

URI, 2005i, *Progress Report for Restoration Activities at URI's Kingsville Dome and Rosita Uranium Facilities in South Texas*, October 14, 2005.

URI, 2005j, *Memorandum from Mark Pelizza to George Rice*, October 12, 2005.

URI, 2005k, *Memorandum from Mark Pelizza to George Rice*, November 18, 2005.

URI, 2005l, *Analyses of Monitor Wells at the Kingsville Dome Mine, 1988 – 2005*, data from Mark Pelizza, October 2005.

URI, 2005m, *Geophysical Logs and Lithologic Descriptions of Wells at the Kingsville Dome Mine*, from Mark Pelizza, October 2005.

URI, 2005n, *Stratigraphic Cross Section, A-A', PAA # 3*, Revised July 6, 2005.

URI, 2005o, *Stratigraphic Cross Section, D-D', PAA # 3*, Revised July 6, 2005.

URI, 2005p, *Letter from Mark Pelizza to Kleberg County Judge Pete De La Garza*, December 2, 2005.

URI, 2005q, *Data provided to the Kleberg County URI Citizen Review Board*, March 31, 2005.

URI 2005r, *Memorandum from Mark Pelizza to George Rice*, December 22, 2005.

URI, 2005s, *Map Showing Locations of Domestic Wells Near KVD Mine*.

URI, 2005t, *Progress Report for Restoration Activities at URI's Kingsville Dome and Rosita Uranium Facilities in South Texas*, April, 2005.

URI, 2005u, *Maps Showing Locations of Well Fields at the KVD Mine*.

URI 2006a, *Memorandum from Mark Pelizza to George Rice*, January 10, 2006.

URI, 2006b, *Progress Report for Restoration Activities at URI's Kingsville Dome and Rosita Uranium Facilities in South Texas*, January, 2006.

URI, 2006c, *Quarterly Analyses of Domestic Wells Near KVD Mine*, data provided by Mark Pelizza.

URI 2006d, *Re-mined Area; Maps and Analyses of Wells*, provided by Mark Pelizza, June 1, 2006.

URI, 2006e, *Progress Report for Restoration Activities at URI's Kingsville Dome and Rosita Uranium Facilities in South Texas*, April, 2006.

URI, 2006f, *Report to the Kleberg County Citizen Review Board*, May 12, 2006.

URI, 2006g, *Lithologic Descriptions of Wells PBL-2 – PBL-6 at the Kingsville Dome Mine*, from Mark Pelizza, June 2006.

## Appendix A Calculation of Groundwater Flow Rates

Groundwater flow rates were calculated with Darcy's Law.

The rates calculated in this appendix are for pre-mining or post-mining conditions. That is, for periods when hydraulic gradients are not altered by injection or extraction associated with mining. The steeper hydraulic gradients<sup>272</sup> resulting from injection and extraction are likely to result in flow rates that are higher than the estimates presented here.

Darcy's Law may be written as follows<sup>273</sup>:

$$q = (T/b) (\Delta h/\Delta L) / n$$

Where:

- T = transmissivity
- b = aquifer thickness
- $\Delta h/\Delta L$  = hydraulic gradient
- n = porosity

### Transmissivity

Transmissivities were calculated from aquifer tests conducted by URI at the KVD Mine (table A-1). The aquifer test data were analyzed with the Theis curve matching method<sup>274</sup>. Examples are shown in figures A-1 through A-3.

The range of transmissivities calculated for this report are comparable to values cited URI and the State<sup>275</sup>.

With the exception of the test performed in PAA-1, the aquifer tests do not appear to have been conducted primarily to estimate transmissivity. URI's primary purpose appears to have been to determine the degree of hydraulic connection between the production zone and the overlying and underlying units<sup>276</sup>.

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<sup>272</sup> URI refers to hydraulic gradients during operations as "extremely steep" (URI, 2005d).

<sup>273</sup> Freeze and Cherry, 1979, pages 59 and 71.

<sup>274</sup> Freeze and Cherry, 1979, page 345.

<sup>275</sup> URI uses a transmissivity value of 0.95 ft/min in its aquifer simulation model (10,205 gpd/ft, URI, 2005a, response to question 17). The State gives an average transmissivity value of 1.5 ft/min (16,140 gpd/ft, TBRC, 1985, page 60).

<sup>276</sup> URI, 1989a, Part 6, Hydrologic Test Procedures and Results, Introduction; and URI, 1997a, Part 6, Hydrologic Test Results and Interpretation, Introduction; and URI, 2005a, response to question 2.

The aquifer test data are far from ideal. In some cases the original measurements are not available and the test data had to be estimated from graphs<sup>277</sup>. Some tests were conducted with more than one pumping well<sup>278</sup>. At PAA-1, off-mine pumping appears to have affected the test results<sup>279</sup>. In some cases two estimates of transmissivity were calculated for the same test (e.g., MW-124A). This was due to uncertainty in determining which data represent the beginning of the test<sup>280</sup>.

Although there are problems with aquifer test data, they are the best data available for estimating the transmissivity of the Goliad Formation in the vicinity of the KVD Mine. Better estimates could be obtained if URI performed additional aquifer tests that were specifically designed to estimate transmissivity.

**Table A-1**  
**Transmissivity Estimates**

Well ID	Date	Transmissivity (ft <sup>2</sup> /min)	Source
PBL-1, PAA-1	8/9 – 8/13, 1983	2.29	URI, 1983(?) <sup>281</sup>
PBL-2, PAA-1	8/9 – 8/13, 1983	1.30	URI, 1983(?) <sup>282</sup>
PBL-3, PAA-1	8/9 – 8/13, 1983	1.41	URI, 1983(?) <sup>283</sup>
PBL-5, PAA-1	8/9 – 8/13, 1983	1.21	TBRC, 1985 <sup>284</sup>
BL-1047, PAA-2	6/26 – 6/27, 1989	0.87	URI, 1989a <sup>285</sup>
MW-45, PAA-2	6/26 – 6/27, 1989	0.06	URI, 1989a <sup>286</sup>
MW-54, PAA-2	7/3 – 7/4, 1989	1.23	URI, 1989a <sup>287</sup>
MW-56, PAA-2	7/3 – 7/4, 1989	0.66	URI, 1989a <sup>288</sup>
MW-72, PAA-3	6/12/1997	0.54	URI, 1997b
MW-72-2, PAA-3	6/12/1997	0.25	URI, 1997b
MW-124A, PAA-3	6/12/1997	1.12	URI, 1997b
MW-124A (2), PAA-3	6/12/1997	0.50	URI, 1997b
MW-125, PAA-3	6/12/1997	2.29	URI, 1997b
MW-125 (2), PAA-3	6/12/1997	1.32	URI, 1997b

<sup>277</sup> See test results for PAA-3 (URI, 1997b).

<sup>278</sup> URI, 1997b, Test Results. The results of tests conducted with more than one pumping well were not used in this report.

<sup>279</sup> URI, 1983(?), section 11.

<sup>280</sup> URI, 1997b, Chart 21.

<sup>281</sup> Table 3.

<sup>282</sup> Table 1.

<sup>283</sup> Table 1.

<sup>284</sup> Pages 58 – 59.

<sup>285</sup> Part 6, Hydrologic Test Procedures and Results, Mini-Pump Test #1.

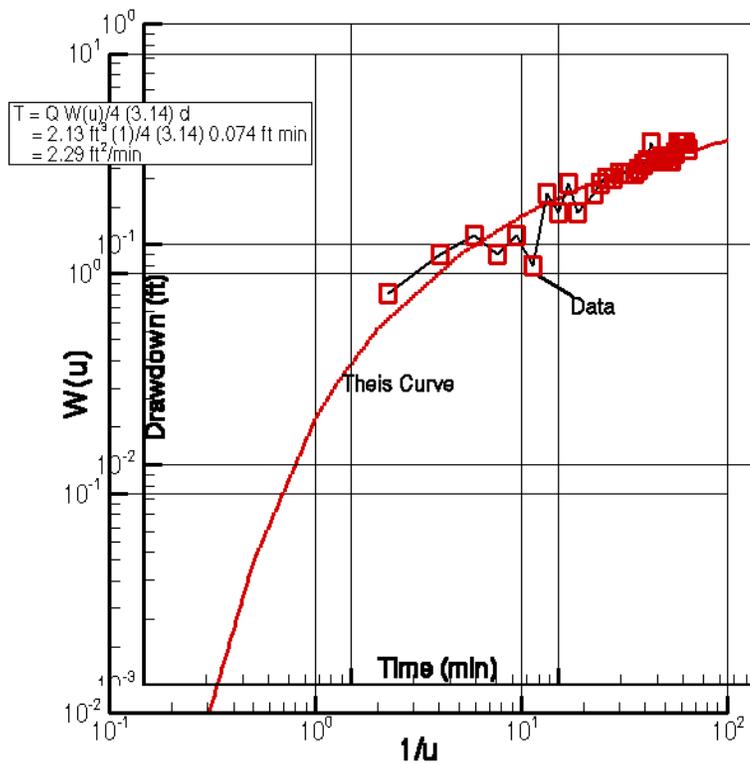
<sup>286</sup> Part 6, Hydrologic Test Procedures and Results, Mini-Pump Test #1.

<sup>287</sup> Part 6, Hydrologic Test Procedures and Results, Mini-Pump Test #4.

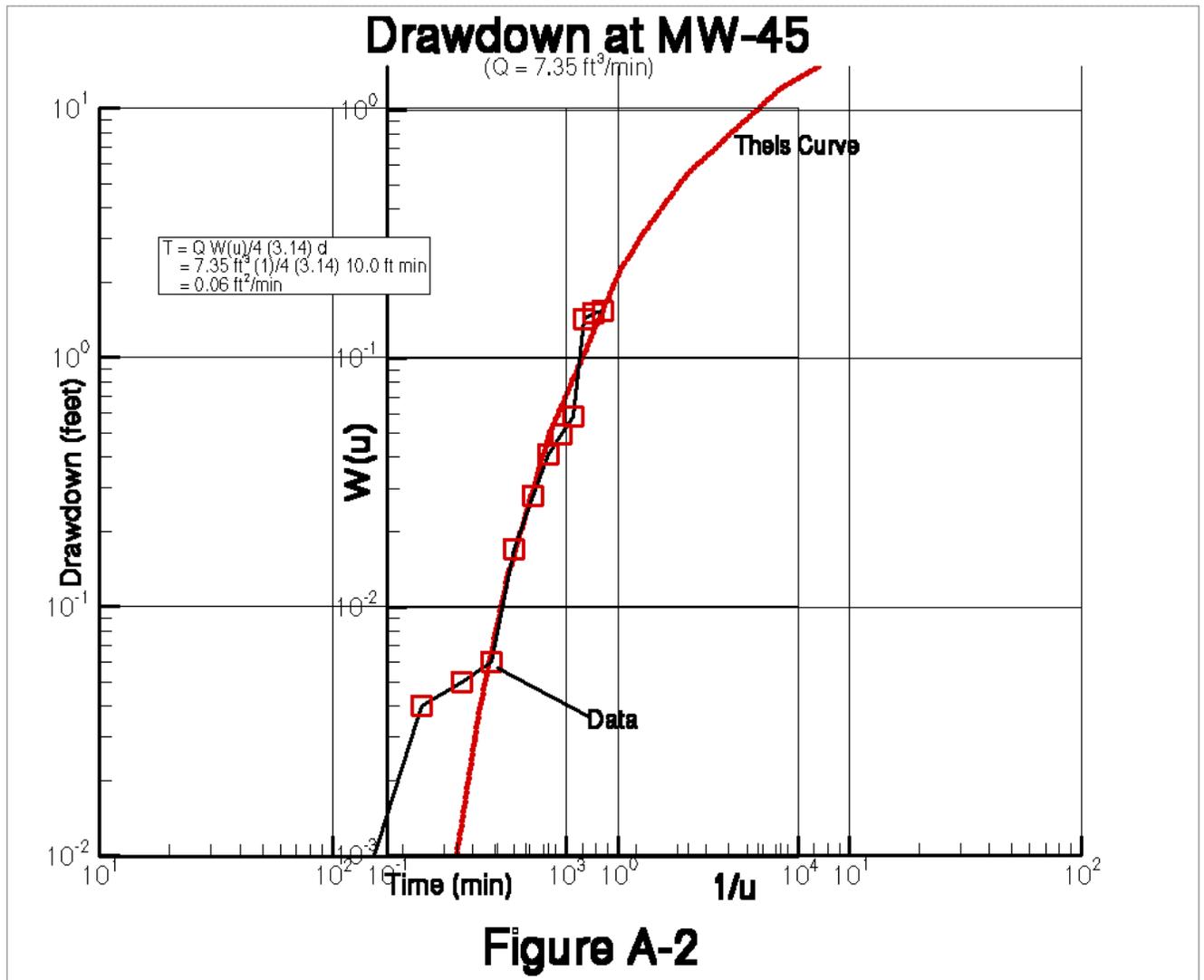
<sup>288</sup> Part 6, Hydrologic Test Procedures and Results Mini-Pump Test #4.

## Drawdown at PBL-1

( $Q = 2.13 \text{ ft}^3/\text{min}$ )

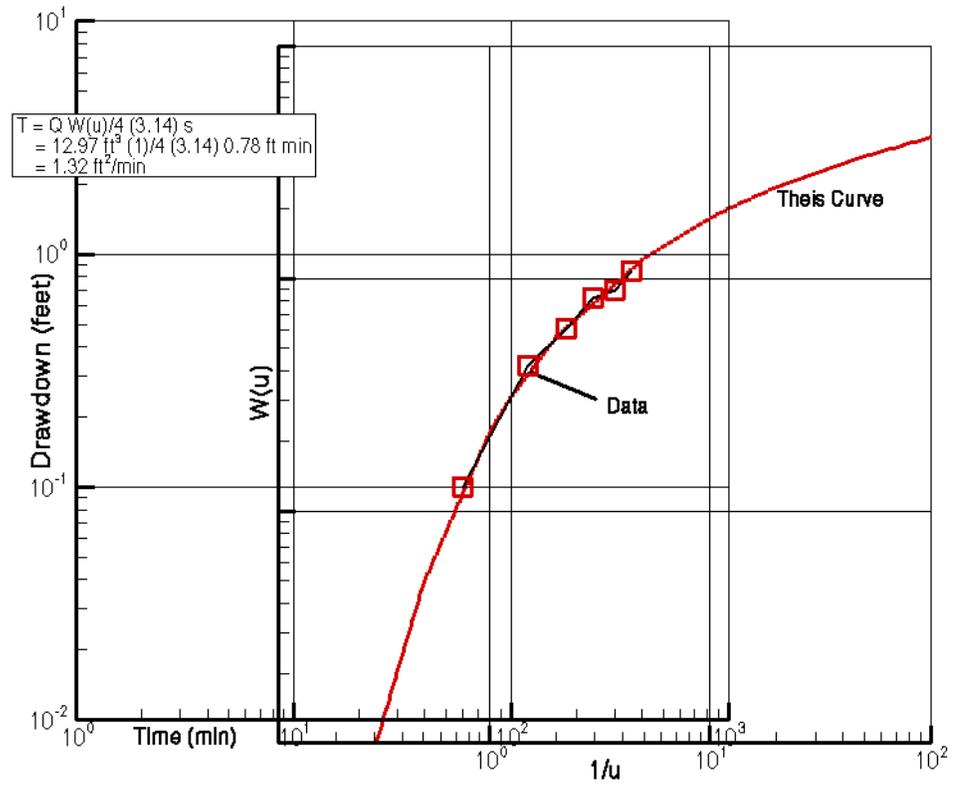


**Figure A-1**



## Drawdown at MW-125 (2)

( $Q = 12.97 \text{ ft}^3/\text{min}$ )



**Figure A-3**

## Aquifer Thickness

Aquifer thickness is the cumulative thickness of the sandy portions of the Goliad Formation uranium production zone. That is, the sandy zones between what URI calls the upper and lower confining units<sup>289</sup>. These sandy portions were identified in well logs<sup>290</sup> and stratigraphic cross sections<sup>291</sup>. Thicknesses estimated for selected wells are presented in table A-2.

**Table A-2**  
**Aquifer Thickness**

Well ID	Thickness (ft)	Source
PBL-2, PAA-2	133	URI, 2006g
PBL-3, PAA-1	100	URI, 2006g
PBL-4, PAA-1	190	URI, 2006g
PBL-5, PAA-1	137	URI, 2006g
PBL-6, PAA-1	118	URI, 2006g
2-AA, PAA-1 <sup>292</sup>	90	URI, 2005m
3-AA, PAA-1	165	URI, 2005m
6-A, PAA-1	150	URI, 2005m
AA-7, PAA-2	125	URI, 2005m
AA-17, PAA-2 <sup>293</sup>	160	URI, 2005m
AA-24, PAA-2	60	URI 2005m and URI, 2005o
AA-27, PAA-2	95	URI, 2005m
AA-28, PAA-2	100	URI 2005m and URI, 2005n

<sup>289</sup> The upper and lower confining units are the D and A clays, respectively. The sands are designated as the A, B, and C sands in cross sections and logs (URI, 2005m; URI, 2005n; TBRC, 1988, pages 14 - 17).

<sup>290</sup> URI, 2005m and 2006g.

<sup>291</sup> URI, 2005n, for example.

<sup>292</sup> Bottom of A sand not clearly identified in logs. Assumed to be at depth of 675 feet.

<sup>293</sup> Bottom of A sand not clearly identified in logs. Assumed to be at depth of 745 feet.

## Hydraulic Conductivity

The hydraulic conductivity (K) is equal to the transmissivity divided by the thickness of the aquifer (T/b). Calculated hydraulic conductivities for four aquifer test wells are shown in table A-3<sup>294</sup>.

**Table A-3  
Hydraulic Conductivity Estimates**

Well ID	Transmissivity (ft <sup>2</sup> /min)	Aquifer Thickness (ft)	Hydraulic Conductivity (ft/min)
PBL-1	2.29	136 <sup>295</sup>	1.7 X10 <sup>-2</sup>
PBL-2	1.30	133	9.8 X10 <sup>-3</sup>
PBL-3	1.41	100	1.4 X10 <sup>-2</sup>
PBL-5	1.21	137	8.8 X10 <sup>-3</sup>

## Hydraulic Gradient

Hydraulic gradients were estimated from piezometric maps produced by URI<sup>296</sup>. The hydraulic gradient in a confined aquifer such as the Goliad is the slope of the piezometric (pressure) surface. This is the slope of the surface represented by water levels in wells completed in the aquifer. Steeper hydraulic gradients result in faster groundwater flow rates. Groundwater flows down the hydraulic gradient. That is, from regions where the piezometric surface is higher to where it is lower.

The hydraulic gradients presented here are for nearly static conditions. That is, for periods when hydraulic gradients were not significantly altered by injection or extraction during uranium production. Injection and extraction result in steeper hydraulic gradients<sup>297</sup>. However, the steepness and direction of these hydraulic gradients is not known because URI has not measured production well water levels during production<sup>298</sup>.

Like the transmissivity data, the data used to estimate hydraulic gradients are not ideal. The pre-mining piezometric maps probably do not represent completely static conditions because they show areas with hydraulic sinks<sup>299</sup>. Sinks are not likely to exist under static conditions. However, these maps represent the best data available for estimating hydraulic gradients for the Goliad Formation in the vicinity of the KVD Mine.

<sup>294</sup> Aquifer thickness data for the additional wells listed in table A-1 has been requested from URI.

<sup>295</sup> Thickness assumed to equal average of other PBL wells.

<sup>296</sup> URI 1987a, PAA-1 Piezometric Contour Map; URI, 1989a, PAA-2 Contour Map of Piezometric Levels; and URI, 1997a, PAA-3 Piezometric Map.

<sup>297</sup> URI refers to hydraulic gradients during operations as "extremely steep" (URI, 2005d).

<sup>298</sup> URI, 2005h, response to question 3.

<sup>299</sup> Hydraulic sinks are enclosed depressions in the piezometric surface.

Table A-4 presents the magnitude and direction of pre-mining hydraulic gradients at the KVD Mine.

**Table A-4**  
**Hydraulic Gradients at the KVD Mine<sup>300</sup>**

Area	Magnitude	Direction
Southeast PAA-1	1/1100 = 0.0009	Northwest
North Central PAA-1	1/200 = 0.005	West
Southeast PAA-2	12/400 = 0.03	Northwest
Central PAA-2	5/800 = 0.006	Northwest
West PAA-2	5/600 = 0.008	East
Southeast PAA-3	5/1000 = 0.005	Northwest
Northwest PAA-3	17/1200 = 0.014	West
North PAA-3	10/800 = 0.012	North

### Porosity

Porosities were measured in cores collected from the KVD Mine<sup>301</sup>. These porosity measurements are presented in table A-5. URI uses a porosity value of 30% in its aquifer simulation model and pore volume calculations<sup>302</sup>.

**Table A-5**  
**Porosities Measured in Cores from the KVD Mine<sup>303</sup>**

Core	Depth (ft)	Porosity (%)
1	547.0 – 547.5	31.8
1	551.0 – 551.25	38.2
1	549.5 – 550.0	26.0
2 & 3	598.5 – 599.0	29.6
2 & 3	601.0 – 601.5	30.8
2 & 3	604.5 – 605.0	27.0
4	574.0 – 574.2	28.5
4	576.0 – 576.2	19.3
4	587.0 – 587.2	28.3

<sup>300</sup> Gradients estimated from: URI 1987a, PAA-1 Piezometric Contour Map; URI, 1989a, PAA-2 Contour Map of Piezometric Levels; and URI, 1997a, PAA-3 Piezometric Map.

<sup>301</sup> URI 2005a, response to question 1.

<sup>302</sup> URI 2005a, response to questions 9 and 17.

<sup>303</sup> URI 2005a, response to question 1. Locations of core holes unknown. Assumed to be from PAA-1.

## Groundwater Flow Rates

Low and high range groundwater flow rates are calculated using the range of values presented above in Darcy's Law.

### Low range

$$q = (T/b) (\Delta h/\Delta L) / n$$

$$T = 0.1 \text{ ft}^2/\text{min}$$

$$b = 150 \text{ ft}$$

$$\Delta h/\Delta L = 0.001$$

$$n = 0.3$$

$$q = (0.1 \text{ ft}^2/\text{min} / 150 \text{ ft}) 0.001/0.3 = 2.2 \times 10^{-6} \text{ ft}/\text{min} = 1.17 \text{ ft}/\text{yr}$$

### High range

$$q = (T/b) (\Delta h/\Delta L) / n$$

$$T/b = K = (2.29 \text{ ft}^2/\text{min})/136\text{ft} = 1.7 \times 10^{-2} \text{ ft}/\text{min}$$

$$\Delta h/\Delta L = 0.012$$

$$n = 0.3$$

$$q = (1.7 \times 10^{-2} \text{ ft}/\text{min}) 0.012/0.3 = 6.8 \times 10^{-4} \text{ ft}/\text{min} = 357 \text{ ft}/\text{yr}$$

## Appendix B Note Regarding URI's Uranium Analyses

The uranium samples collected by URI are analyzed by two laboratories. Most of the samples are analyzed by URI's in-house laboratory. Other samples are analyzed by Jordan Laboratories of Corpus Christi, Texas.

In general, pre-mining (background) uranium analyses were performed by Jordan Laboratories. Post-mining uranium analyses of samples from monitor wells (to detect excursions) and baseline wells (to monitor restoration progress) have been performed by URI's in-house laboratory. URI intends to use Jordan Laboratories for restoration verification analyses<sup>304</sup>.

URI uses a Hach DR/4000 V spectrophotometer to analyze uranium samples. Although this machine is not specifically designed to analyze uranium, it is possible to do so if the user develops a 'user entered' program<sup>305</sup>.

It is not clear what URI's uranium detection limit is. URI has stated that it has complete confidence in results greater than 1 mg/L, but less confidence in lower results<sup>306</sup>. At some point, uranium concentrations are so low that URI's analytical method is completely unreliable. That point has not been determined.

The uranium values reported by URI's in-house laboratory should be treated with caution. The lower the concentration, the less reliable the analysis.

Recent uranium analyses for well BL-547 point to other problems with URI's in-house uranium analyses. URI's in-house laboratory reported a value of 1.4 mg/L. This value was reported to the State<sup>307</sup> for a sample collected on 2/9/06. A few days later (2/13/06) the County and URI split samples from well BL-547. The uranium results reported by two outside laboratories were 35.2 mg/L and 33.0 mg/L<sup>308</sup>. Then, URI's in-house laboratory analyzed a sample collected on 5/31/06. The reported uranium concentration was 11.2 mg/L.

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<sup>304</sup> Personal communication, Mark Pelizza of URI, December 2005.

<sup>305</sup> Personal communication, Scott Talbot of Hach Instruments, December 2005.

<sup>306</sup> Personal communication, Mike Hendrix of URI, December 2005.

<sup>307</sup> URI, 2006e.

<sup>308</sup> See appendix F.

### Appendix C Calculation of 95% UTLs for EC Data

The method used to calculate tolerance intervals, or upper tolerance limits (UTL), was taken from an EPA publication: *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities*, April 1989.

$$\text{UTL} = X + KS$$

Where:

X = mean

S = standard deviation

K = one-sided normal tolerance factor (from EPA, 1989, table 5, appendix B).

S/X = coefficient of variation

(if data are normally distributed, S/X < 1.0; EPA, 1989 page 4-7)

#### Calculations for PAA-1

**Table C-1  
Pre-mining ECs in PAA-1 Monitor Wells**

Well ID	EC (µmhos)
MW-1	1584
MW-2	1605
MW-3	1725
MW-4	1549
MW-5	1572
MW-6	1592
MW-7	1577
MW-8	1613
MW-9	1575
MW-10	1614
MW-11	1613
MW-12	1563
MW-13	1563
MW-14	1537
MW-15	1730
MW-16	1610
MW-17	1670

**Table C-1**  
**Pre-mining ECs in PAA-1 Monitor Wells (concluded)**

Well ID	EC (µmhos)
MW-18	1570
MW-19	1590
MW-20	1590
MW-21	1660
MW-22	1630
MW-23	1630
MW-24	1670
MW-25	1670
MW-26	1720
MW-27	1615

$$X = 1616.2$$

$$S = 53.17$$

$$S/X = 0.03$$

$$K = 2.26$$

$$95\% \text{ UTL} = X + KS = 1616.2 + 53.17 (2.26) = 1736$$

**Calculations for PAA-2**

**Table C-2**  
**Pre-mining ECs in PAA-2 Monitor Wells**

Well ID	EC (µmhos)
MW-31	1610
MW-32	1620
MW-33	1600
MW-34	1620
MW-35	1830
MW-36	1580
MW-37	1610
MW-38	1620
MW-39	1770
MW-40	1740
MW-41	1730
MW-42	1570
MW-43	1760
MW-44	1860

**Table C-2**  
**Pre-mining ECs in PAA-2 Monitor Wells (concluded)**

<b>Well ID</b>	<b>EC (µmhos)</b>
MW-45	1940
MW-47	1860
MW-48	2020
MW-49	1690
MW-50	1610
MW-51	1640
MW-52	1610
MW-53	1580
MW-54	1620
MW-55	1590
MW-56	1610
MW-57	1630
MW-58	1550
MW-59	1590
MW-60	1490
MW-61	1570
MW-62	1570
MW-63	1550
MW-64	1560
MW-65	1580
MW-66	1590
MW-67	1580
MW-68	1590
MW-69	1610
MW-70	1590
MW-71	1570

X = 1647.8

S = 115.1

S/X = 0.07

K = 2.126

95% UTL = X + KS = 1647.8 + 115.1 (2.126) = 1892.5

## Calculations for PAA-3

**Table C-3**  
**Pre-mining ECs in PAA-3 Monitor Wells**

<b>Well ID</b>	<b>EC (<math>\mu\text{mhos}</math>)</b>
MW-72	2350
MW-73	2370
MW-74	2420
MW-75	2460
MW-76	1780
MW-77	2410
MW-78	2450
MW-79	1970
MW-80	2030
MW-81	2410
MW-82	1760
MW-83	1700
MW-84	2080
MW-85	1820
MW-86	2590
MW-87	1680
MW-88	2240
MW-89	2410
MW-90	2200
MW-91	2000
MW-92	2080
MW-93	1750
MW-94	1760
MW-95	1900
MW-96	2020
MW-97	1920
MW-98	1750
MW-99	1900
MW-100	1720
MW-101	1790
MW-102	1770
MW-103	1710
MW-104	1720
MW-105	1710
MW-106	1710

**Table C-3**  
**Pre-mining ECs in PAA-3 Monitor Wells (concluded)**

<b>Well ID</b>	<b>EC (<math>\mu\text{mhos}</math>)</b>
MW-107	1790
MW-108	1600
MW-109	1940
MW-115	2130
MW-116	2130
MW-117	2510
MW-118	1810
MW-119	1920
MW-120	1860
MW-121	2050
MW-122	2140
MW-123	2050
MW-124	2240
MW-125	2340

X = 2017.3

S = 274.1

S/X = 0.14

K = 2.07

95% UTL = X + KS = 2017.3 + 274.1 (2.07) = 2585

**Appendix D**  
**Injection in the Vicinity of Supplementary Baseline Wells 5525 and 5425**

102 mg/L uranium was detected in a sample collected from PAA-2 supplementary well 5525. The sample was collected on November 6, 1996<sup>309</sup>. Production in PAA-2 began in April 1996. A number of injection wells were operating near well 5525 before the well was sampled. The closest injection wells are listed in table D-1.

**Table D-1**  
**Injection Wells Within 100 Feet of Well 5525**

Injection well ID	Distance/direction from well 5525 (feet) <sup>310</sup>	Date injection began <sup>311</sup>	Minimum injection rate (gallons per day) <sup>312</sup>	Maximum injection rate (gallons per day)
2183/5521	100/South	10/4/96	10,800	178,700
5522	90/Southeast	9/28/96	1400	118,200
5524	65/Northeast	9/27/96	14,400	218,200
5532	75/West	10/26/96	34,560	121,700
2182/5533	55/North	10/17/96	63,600	113,900

Similarly, 66.2 mg/L uranium was detected in a sample collected from PAA-2 supplementary well 5425. The sample was collected on December 2, 1996<sup>313</sup>. Production began in PAA-2 in April 1996. A number of injection wells were operating near well 5425 before the well was sampled. The closest injection wells are listed in table D-2.

<sup>309</sup> URI, 1989a, uranium analysis for well 5525, in section titled *Ground water Analysis Reports (All Baseline and Monitor Wells)*.

<sup>310</sup> Distances and directions from URI, 2005c.

<sup>311</sup> Injection dates and rates from URI, 2005b.

<sup>312</sup> The injection rates are for the period up to the date the sample was collected from well 5525 (November 6, 1996).

<sup>313</sup> URI, 1989a, uranium analysis for well 5425, in section titled *Ground water Analysis Reports (All Baseline and Monitor Wells)*.

**Table D-2  
Injection Wells Within 100 Feet of Well 5425**

Injection well ID	Distance/direction from well 5425 (feet) <sup>314</sup>	Date injection began <sup>315</sup>	Minimum injection rate (gal per day) <sup>316</sup>	Maximum injection rate (gal per day)
5424	65/Southwest	11/6/96	33,800	143,600
2169/5131	25/Northwest	11/9/96	13,800	173,600

<sup>314</sup> Distances and directions from URI, 2005c.

<sup>315</sup> Injection dates and rates from URI, 2005b.

<sup>316</sup> The injection rates are for the period up to the date the sample was collected from well 5425 (December 2, 1996).

## Appendix E State Restoration Range Table

Table E-1 is the Restoration Range Table contained in the first permit issued for the Kingsville Dome Mine<sup>317</sup>. It is not clear how all of these concentrations were established. In some cases (e.g., arsenic, calcium) they are the lowest and highest concentrations detected in either PAA-1 or PAA-2<sup>318</sup>. In other cases (e.g., uranium) neither the lowest or highest concentrations are used<sup>319</sup>.

The concentrations contained the State restoration tables for each PAA (table 7.2-1) are within the ranges given in the Restoration Range Table.

**Table E-1  
Restoration Range Table**

Constituent/Property <sup>320</sup>	Low	High
Calcium	5.15	74
Magnesium	2.8	10
Sodium	288	352
Potassium	4.72	12.1
Carbonate	0	71
Bicarbonate	142	505
Sulfate	13	310
Chloride	196	352
Fluoride	0.49	1.10
Nitrate	0.01	5.8
Silica	9.1	22
pH <sup>321</sup>	7.37	9.5
TDS	880	1230
EC <sup>322</sup>	1470	2100
Alkalinity <sup>323</sup>	205	444

<sup>317</sup> TWC, 1990a, Table 2, page 13.

<sup>318</sup> Samples from PAA-3 were not available when the Restoration Range Table was produced. The table is in a permit that was issued in 1990 (TWC, 1990a). The first samples from PAA-3 were collected in 1997 (URI, 1997a).

<sup>319</sup> Compare uranium values in the Restoration Range Table with those in the PAA-2 Ground Water Analysis Report Summary (URI, 1989a)

<sup>320</sup> All units are mg/L except where noted.

<sup>321</sup> pH given in standard units.

<sup>322</sup> EC (electrical conductivity) units =  $\mu\text{mhos/cm}$ .

<sup>323</sup> Alkalinity were not specified but are assumed to be mg/L as  $\text{CaCO}_3$ .

**Table E-1**  
**Restoration Range Table (Table 2)**  
**(concluded)**

<b>Constituent/Property</b>	<b>Low</b>	<b>High</b>
Arsenic	<0.001	0.023
Cadmium	<0.001	0.0034
Iron	<0.01	0.26
Lead	<0.001	0.014
Manganese	<0.001	0.08
Mercury	<0.001	0.01
Selenium	<0.001	0.072
Ammonia	0.01	13
Uranium	0.002	1.89
Molybdenum	<0.01	0.84
Ra 226 <sup>324</sup>	0.01	202

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<sup>324</sup> Ra 226 units = pCi/L.

## Appendix F Split Samples

On February 6<sup>th</sup> and 13<sup>th</sup>, 2006 representatives of the CRB and URI split groundwater samples from nine wells. The CRB's samples were analyzed by ACZ Laboratories of Steamboat Springs, Colorado. URI's samples were analyzed by Jordan Laboratories of Corpus Christi, Texas. Analytical results are presented in table F-1.

**Table F-1  
CRB and URI Analyses of Split Samples**

Well ID	Analyte	CRB Result <sup>325</sup>	URI Result
Cumberland Domestic	Calcium	18.7	18
	Alkalinity <sup>326</sup>	251	242
	Chloride	205	202
	Sulfate	200	217
	EC <sup>327</sup>	1580	1570
	Molybdenum	0.0129	<0.1
	Selenium	0.012	0.012
	Uranium	0.0106	0.013
	Radon-222	380	222
	Radium-226	0.22	0.1
Robertson Domestic	Calcium	17.6	17
	Alkalinity	225	217
	Chloride	320	312
	Sulfate	300	300
	EC	2000	2010
	Molybdenum	0.0157	<0.1
	Selenium	<0.001	<0.001
	Uranium	<0.0001	0.001
	Radon-222	420	254
	Radium-226	0.3	0.2

<sup>325</sup> The units for all analytical results are mg/L except EC ( $\mu\text{mhos/cm}$ ), and radon-222 and radium-226 (pCi/L).

<sup>326</sup> Total alkalinity as  $\text{CaCO}_3$ .

<sup>327</sup> EC = electrical conductivity.

**Table F-1 (continued)**  
**CRB and URI Analyses of Split Samples**

<b>Well ID</b>	<b>Analyte</b>	<b>CRB Result</b>	<b>URI Result</b>
BL-547	Calcium	424	460
	Alkalinity	558	535
	Chloride	610	597
	Sulfate	1600	1600
	EC	4920	5010
	Molybdenum	1.9	2.0
	Selenium	<0.002	0.001
	Uranium	35.2	33.0
	Radon-222	7100	2990
	Radium-226	75	69
	BL-8506	Calcium	16
Alkalinity		271	266
Chloride		226	219
Sulfate		190	186
EC		1710	1570
Molybdenum		0.018	<0.1
Selenium		0.081	0.074
Uranium		0.0366	0.034
Radon-222		NA <sup>328</sup>	
Radium-226		NA	4.0
I-8	Calcium	117	113
	Alkalinity	265	254
	Chloride	120	114
	Sulfate	170	170
	EC	1120	1130
	Molybdenum	0.959	1.1
	Selenium	<0.001	<0.001
	Uranium	0.651	0.746
	Radon-222	NA	
	Radium-226	NA	101

<sup>328</sup> NA = not analyzed.

**Table F-1 (continued)**  
**CRB and URI Analyses of Split Samples**

Well ID	Analyte	CRB Result	URI Result
I-11	Calcium	136	128
	Alkalinity	273	265
	Chloride	90	90
	Sulfate	260	251
	EC	1190	1210
	Molybdenum	1.44	1.6
	Selenium	< 0.001	<0.001
	Uranium	1.10	1.10
	Radon-222	220,000	12,400
	Radium-226	140	143
	MW-61	Calcium	65.1
Alkalinity		264	263
Chloride		490	489
Sulfate		120	127
EC		2540	2290
Molybdenum		0.0019 (J) <sup>329</sup>	<0.1
Selenium		0.001 (J)	0.002
Uranium		0.0117	0.034
Radon-222		NA	
Radium-226		NA	2.4
MW-76	Calcium	33.5	32
	Alkalinity	155	152
	Chloride	300	316
	Sulfate	520	513
	EC	2500	2320
	Molybdenum	0.04	0.1
	Selenium	<0.001	<0.001
	Uranium	0.0643	0.004
	Radon-222	NA	
	Radium-226	NA	2.0

<sup>329</sup> J value = concentration is greater than the detection limit but less than the reporting limit. Reporting limits are generally three to ten times greater than detection limits.

**Table F-1 (concluded)**  
**CRB and URI Analyses of Split Samples**

<b>Well ID</b>	<b>Analyte</b>	<b>CRB Result</b>	<b>URI Result</b>
MW-87	Calcium	18	18
	Alkalinity	260	253
	Chloride	234	230
	Sulfate	200	199
	EC	1620	1630
	Molybdenum	0.0164	<0.1
	Selenium	0.017	0.016
	Uranium	0.0411	0.016
	Radon-222	3400	1970
	Radium-226	1.8	6.9

**Appendix G**  
**URI Comments on Draft Report of April 10, 2006**

URI produced a document commenting on the draft report of April 10, 2006: *Report to the Kleberg County Citizen Review Board*, May 12, 2006<sup>330</sup>. The first three pages of the document are appended below. An electronic version of the complete document (pdf) is available upon request. Responses to URI's comments are presented in appendix H.

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<sup>330</sup> URI, 2006f.

## REPORT TO THE KLEBERG COUNTY CITIZEN REVIEW BOARD

URI, Inc.

May 12, 2006

### Introduction, Summary and Recommendations

URI, Inc. ("URI") is pleased to present this report to the Kleberg County Citizen Review Board to supplement the report by Mr. George Rice entitled *Effects of URI's Kingsville Dome Mine on Groundwater Quality*, April 10, 2006. This report is organized in tab format, with each tab number denoting a section that corresponds sequentially to the Conclusions or Recommendation found in §8.0 of the Rice Report. As needed, each tabbed section includes its own attachments.

URI has incorporated two additional reports that were prepared specifically to address issues raised in the Rice Report. Section 4 was largely prepared by Mr. Craig Bartels, P.E., P.G. Mr. Bartels is President of HRI, Inc., URI's New Mexico operating subsidiary. He is a Hydrologist and Geochemist with over thirty years of uranium ISR experience in Texas, Wyoming, Nebraska and Australia. Section 16 includes an attached report by Mr. Hal Demuth and Dr. Janet Schramke, Ph. D. Mr. Demuth and Dr. Schramke have been performed numerous restoration analysis in conjunction with closure plans submitted to Nebraska and Wyoming State officials and the Nuclear Regulatory Commission.

In summary, URI's responses to §8.0 of the Rice Report follow.

1. The pre-mining quality of groundwater at the Kingsville Dome ("KVD") site was poor because it is highly mineralized with naturally-occurring uranium and the uranium decay products ("progeny")  $^{226}\text{Ra}$  ("radium") causing the water to exceed U.S. EPA Maximum Contaminant Levels (MCLs). In addition, data from the KVD site and from other similar uranium sites demonstrate that  $^{222}\text{Rn}$  ("radon") eliminates pre-mining groundwater from use as a drinking water source.
2. During mining concentrations of uranium, molybdenum, bicarbonate, calcium, chloride, sulfate, and Total Dissolved Solids (Conductivity) were significantly higher than pre-mining concentrations and provide a distinct chemical signature that distinguishes "leach solution" from unaffected groundwater.
3. URI's in-house analysis procedure for uranium is thoughtfully designed to provide quantitative results that are reliable for their intended purpose.
4. Pre-mining groundwater flow rates at the KVD Mine averaged about 30 feet per year. Flow rates are much higher during mining due to the steep hydraulic gradients produced by injection and extraction wells, but these local gradients have little impact on the regional gradient a short distance from the wellfields.

5. URI's sampling protocol allows many wells to be sampled at a high frequency that would not be possible with less productive methods such as field filtration and preservation. The sampling techniques used have been accepted by regulatory agencies in Texas and other states. URI has not observed any difference in the analytical results from groundwater samples that are collected with airlifting vs. pumping.
6. The method for determining excursions at the Kingsville Dome Project is grounded in TCEQ regulatory experience and industry practice which established that the method adequately screens for the presence of leach solution yet minimizes the potential for false positives.
7. Years of ISR experience have demonstrated that monitor wells detect excursions regardless of some dilution and attenuation because the signature of the mining solution is strong as compared to natural groundwater quality and highly mobile control parameters are chosen because they are early indicators.
8. Upper Tolerance Limits (UTLs) are fundamentally flawed because they flag false excursions and offer no additional protection of water outside the exempted area.
9. There is no reason to believe that any domestic well has been affected by mining solutions emanating from the KVD Mine.
10. Beginning in 1998, URI began to systematically sample extraction wells in new wellfields to supplement the baseline information obtained during production area development. While this data is not used in URI's Permit or Production Area Authorizations, it does provide insight to the pre-mining water quality in the ore because the wellfield patterns are carefully located in the ore and baseline wells are not.
11. If groundwater restoration efforts in any production area fail to meet the requirements of a Restoration Table, URI will be required to comply with the rules of the State of Texas to assure that restoration efforts do not impact water resources and comply with the provisions agreed to by Kleberg County in the Settlement Agreement.
12. If the numeric values for calcium, sulfate, molybdenum (moly) and pH were amended to the currently restored values in PAA1, the use quality in the mine zone would be unchanged.
13. URI has satisfied its quantity obligation under the Settlement Agreement.
14. Of 48 baseline wells, only one well, I-11, was suitable for use as drinking, livestock, or irrigation before mining began. URI will conduct additional restoration at well I-11 until the water quality in the well is again suitable for use as a source of drinking, livestock, or irrigation water.

15. The trace metals that are most prominently elevated during the mining process are uranium and molybdenum (moly). Moly and, to a lesser extent, uranium remain in the water above their pre-mining levels. “Well above” is an undefined and relative term and not particularly useful for the purpose of determining restoration goals.

16. Even if restoration does not remove all elevated ISR constituents in groundwater, dispersion and attenuation make it highly unlikely that groundwater could migrate beyond the mine boundaries after natural hydraulic gradients are reestablished.

URI recommends that additional work be performed to provide satisfactory answers to the questions raised in both the Rice Report and this supplementary report as listed below.

1. URI increase analysis of  $^{222}\text{Rn}$  in water near to the KVD mine and provide this information to the CRB. That the CRB notify local property owners of adverse natural water conditions when uranium,  $^{226}\text{Ra}$  or  $^{222}\text{Rn}$  exceeds MCLs.

2. A series of sequential samples be taken from individual wells using both the airlift method and the pump method. URI would treat these samples identically with respect to delivery and laboratory analysis. The side by side results would be presented to the CRB.

3. Perform a numerical modeling study to assess and document the site-specific concentration reductions that are achieved under natural conditions due solely to hydrodynamic dispersion (e.g., MODFLGN/MODPATH modeling).

4. Conduct field analysis to further assess the in-situ reduction potential within, or downgradient of the ISL wellfields. An example would be coring and laboratory analysis to assess pyrite concentrations. Such an analysis could prove useful since pyrite is dominant in control of redox conditions. Based on the results, perform a geochemical modeling study (e.g., PHREEQC) to assess geochemical attenuation.

5. Perform detailed tracer tests with conservative and non-conservative tracers to assess the transport of each species. Assess the results with regard to the primary constituents of concern at Kingsville Dome.

6. Evaluate the feasibility for reducing oxygen concentrations in the restoration flow by installing a nitrogen blanket on the surge tanks or an oxygen scavenging system in the plant downstream of the RO units.

7. Consider the use of  $\text{H}_2\text{S}$ , or similar reductant or oxygen scavenger, to reduce the concentrations of molybdenum and uranium in the vicinity of Well I-II.

## Appendix H Response to URI's Comments on Draft Report of April 10, 2006

URI's comments are contained in: *Report to the Kleberg County Citizen Review Board*, May 12, 2006<sup>331</sup>. A summary of those comments is presented in appendix G.

URI made sixteen comments and seven recommendations for additional work. Each comment and recommendation is addressed below.

### URI comment 1

This comment concerns the pre-mining quality of groundwater at the KVD Mine and radon-222.

URI's initial statement "*The contamination that exists in leach solution is not significantly different from native groundwater within the orebody.*" is incorrect.

Although the constituents in the leach (mining) solution and the native groundwater are the same (e.g., sulfate, uranium, molybdenum), the concentrations of these constituents are much higher in the leach solution than in the native groundwater. Table H-1 compares constituent concentrations in pre-mining groundwater at each PAA with their concentrations in a typical mining solution.

**Table H-1  
Comparison of Constituent Concentrations in  
Pre-mining Groundwater and in Typical Mining Solution<sup>332</sup>**

Constituent	Range of pre-mining concentrations <sup>333</sup>			Concentrations in Mining Solution
	PAA-1	PAA-2	PAA-3	
Uranium	0.002 – 0.927	<0.001 – 3.75	<0.001 – 1.54	80
Molybdenum	<0.01 – 0.20	<0.01 – 0.84	<0.01 – 3.50	10
Chloride	196 - 352	198 – 336	138 – 443	600
Bicarbonate	142 - 343	246 – 505	95 – 321	800
Sulfate	81 - 257	13 – 239	183 – 557	1200
Calcium	5.15 – 29.3	8.4 – 74	10 – 34	400
EC	1549 - 2100	1490 – 2020	1120 – 2820	4000

<sup>331</sup> URI, 2006f.

<sup>332</sup> See tables 4.1-1 through 4.1-6, and 4.2-1.

<sup>333</sup> All units mg/L except EC (µmhos/cm) and pH (SU).

URI also states: *Water quality in the aquifer surrounding the KVD exempted area boundary will not be affected by the ISR operations because regulations require that injected solutions be limited to the mineralized area.* This is an odd argument. It is analogous to saying: 'Officer, I could not have been doing 85 mph. The speed limit is clearly posted – 65 mph.' Few people, if any, would take this seriously.

On the other hand, the issue of radon-222 does merit attention. URI contends that high concentrations of radon-222 probably existed at and near the ore bodies before mining began. This is because uranium in the ore produces radon-222. In support of this argument, URI presents pre-mining data from its Vasquez Mine. These data show that high concentrations of radon-222 existed at the Vasquez Mine before any mining began. URI also cites pre-mining data from uranium sites in Nebraska<sup>334</sup>, New Mexico, Texas and Wyoming. Assuming that the mechanism that produces radon-222 is the same at all of these sites (the decay of uranium in the ore), it is reasonable to conclude that pre-mining concentrations of radon-222 were also high at the KVD Mine. At most locations near the ore bodies, radon-222 concentrations probably exceeded the EPA primary standard of 300 pCi/L.

## URI comment 2

This comment concerns the effects of mining on groundwater quality, and the processes that will act to restore groundwater quality after mining ceases.

URI claims that after mining ceases, reducing conditions will be re-established. This will result in a decrease in the concentrations of uranium and other redox<sup>335</sup> sensitive constituents. This may be true. However, the re-establishment of reducing conditions, if it occurs, may take a long time.

There is little if any indication that reducing conditions are being re-established at the KVD mine<sup>336</sup>. It has been more than five years since mining ceased in PAAs 1 and 2. Concentrations of uranium, molybdenum, and sulfate remain well above their baseline levels<sup>337</sup>. Radium-226 concentrations also remain elevated<sup>338</sup>. The re-establishment of reducing conditions will not decrease radium-226 concentrations<sup>339</sup>.

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<sup>334</sup> This is a mistake. URI had no radon data from Nebraska. Personal communication with mark Pelizza, June 2, 2006.

<sup>335</sup> Redox sensitive constituents are those that are affected by changes in the oxidation-reduction potential of the groundwater. They include uranium, molybdenum, and sulfate.

<sup>336</sup> URI has measured the oxidation/reduction potential of groundwater at the KVD Mine, but records of the measurements were discarded (Mike Maxson of URI, December 2005).

<sup>337</sup> See table 7.4-1.

<sup>338</sup> Compare values in tables 7.3.5.1-1 and 7.3.5.2-1 with the values in appendix F.

<sup>339</sup> Demuth and Schramke, 2006, pages ii and 32.

If they are not cleaned up, the remaining contaminants pose a risk to nearby groundwater resources. After restoration ceases they may be transported beyond the mine boundaries<sup>340</sup>.

### URI Comment 3

URI claims that its in-house uranium analyses are suitable for their intended purposes<sup>341</sup>. This is not correct. These analyses are not suitable for reporting the progress of restoration to the State. As URI states in its comment, the sensitivity of its in-house uranium analysis procedure is about 1 mg/L. However, many of the uranium values that URI reports to the State in its quarterly restoration progress reports are much lower than 1 mg/L<sup>342</sup>. These low uranium values are unreliable.

Recent uranium analyses for well BL-547 point to other problems with URI's in-house uranium analyses. When it analyzed a sample collected on 2/9/06, URI's in-house laboratory reported a value of 1.4 mg/L. This value was reported to the State<sup>343</sup>. However, a few days later (2/13/06) the County and URI split samples from well BL-547. The uranium results reported by two outside laboratories were 35.2 mg/L and 33.0 mg/L<sup>344</sup>. Then, URI's in-house laboratory analyzed a sample collected on 5/31/06. The reported uranium concentration was 11.2 mg/L.

The uranium values that URI reports to the State should be reliable. Failing this, the analyses should be accompanied by a statement that explains why they may not be reliable.

### URI Comment 4

This comment consists of a number of claims regarding groundwater flow rates:

- 1) The pre-mining regional hydraulic gradient at the KVD Mine was low, approximately 0.0008.
- 2) Although pumping associated with mining has altered the hydraulic gradient at the mine, it will return to its pre-mining configuration after mining ceases.
- 3) The pre-mining groundwater flow rate was approximately 10 ft/yr<sup>345</sup>.

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<sup>340</sup> See section 7.5.

<sup>341</sup> A discussion of URI's in-house uranium analyses is presented in appendix B.

<sup>342</sup> In its latest restoration progress report, the uranium values reported by URI range from 0.00 mg/L to 3.20 mg/L (URI, 2006e, table 1).

<sup>343</sup> URI, 2006e.

<sup>344</sup> See appendix F.

<sup>345</sup> The formula that URI uses for hydraulic conductivity ( $K = k/\mu$ ) is a 'shorthand' version that may lead to confusion. The correct formula is:  $K = k\rho g/\mu$ , where  $\rho$  is the density of water and  $g$  is the acceleration due to gravity (Freeze and Cherry, 1979, page 27).

- 4) Only the aquifer test performed in 1983 should be used to estimate hydraulic conductivity at the KVD Mine.
- 5) The aquifer thicknesses used to estimate hydraulic conductivities in the draft report were inappropriate.

#### Item 1, Regional gradient

It should be noted that the pre-mining regional hydraulic gradient is not the natural gradient. Under natural conditions, groundwater in the Goliad Aquifer near the KVD Mine flowed toward the coast. Pumpage in the vicinity of Kingsville has reversed the hydraulic gradient. Groundwater in the Goliad Aquifer near the KVD Mine now flows toward Kingsville<sup>346</sup>.

The pre-mining gradient shown in URI's figure 1 was measured in 1983 and is based on water level measurements from six wells. The wells are in or near PAAs 1 and 2, but not in PAA 3.

Based on this limited information it is reasonable to conclude that the general, pre-mining regional hydraulic gradient was 0.0008, toward the northwest. However, this does not preclude the existence of local gradients that 1) may have been steeper, and 2) may have caused groundwater to flow in other directions. Six wells are simply not enough to determine the nature of any local gradients.

More detailed data on hydraulic gradients were collected as URI installed baseline and monitor wells in each PAA. URI measured water levels in these wells before mining began. Hydraulic gradient maps based on these data are presented in the permit applications for PAAs 1, 2, and 3. These maps clearly show the existence of local hydraulic gradients that deviate from the general regional gradient.

URI argues that the more detailed hydraulic gradient maps are not reliable indicators of pre-mining conditions. To a certain extent, this is correct. This issue was discussed in the draft report<sup>347</sup>. Nonetheless, these maps represent the best information available. Until URI produces better maps, these are the ones that should be used, keeping their deficiencies in mind<sup>348</sup>.

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<sup>346</sup> TBRC, 1985, page 55.

<sup>347</sup> See appendix A.

<sup>348</sup> URI did produce additional hydraulic gradient maps for PAA-3 (personal communication with Ron Grant of URI, November 2005). The water level data were collected in May of 1998, about a month before mining began. However, these maps also indicate the presence of hydraulic gradients much greater than 0.0008. These maps are not as useful as the maps contained in the PAA permit applications because they only show water level data for monitor wells. They contain no data for baseline wells.

The questions regarding existing gradients could be resolved if URI measured static, or as nearly static as practical, water levels at and around the mine. If URI does this, it should be done in cooperation with the CRB.

Also, pumping beyond the mine boundary may affect future hydraulic gradients. Pumping around Kingsville is known to have greatly affected the regional hydraulic gradient in the past. Continued pumping around Kingsville, as well as pumping in the immediate vicinity of the mine, may continue to affect both regional and local hydraulic gradients.

#### Item 2, Pre-mining gradients will be re-established after mining ceases

After mining ceases, the effects that mining has had on hydraulic gradients will dissipate. However, the length of time required for the effects to dissipate is not known.

In addition, the post-mining gradients will not be identical to pre-mining gradients because the conditions that created the pre-mining gradient have changed since 1983. Continued pumping around Kingsville and in the vicinity of the mine has likely continued to alter hydraulic gradients. The only way to know what the post-mining gradients will be is to monitor them until they have stabilized.

#### Item 3, Groundwater flow rates

URI appears to believe that there was only one groundwater flow rate before mining began and that this flow rate will be re-established some time after mining ends. This is unlikely.

Groundwater flow rates are a function of the hydraulic gradient, the hydraulic conductivity, and the effective porosity of the aquifer. In addition to variations in hydraulic gradients, one would expect variations in the hydraulic conductivity. As stated in section 2.1, the Goliad Aquifer was deposited by meandering streams. As a result, hydraulic conductivities within the Goliad are likely to vary over a wide range.

The wide variations in hydraulic gradients and conductivities will result in a wide range of flow rates. Estimated groundwater flow rates at the KVD Mine range from 1 ft/yr to 350 ft/yr<sup>349</sup>.

#### Item 4, Aquifer tests

URI has conducted a number of aquifer tests at the KVD Mine. However, URI claims that only the test conducted at PAA-1 in 1983 should be used to estimate

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<sup>349</sup> See section 2.1 and appendix A.

hydraulic conductivity (transmissivity)<sup>350</sup>. According to URI, the tests performed in PAAs 2 and 3 were not conducted for the purpose of estimating flow rates and the data from them should not be used for that purpose.

It is true that the tests performed in PAAs 2 and 3 are not conducted for the purpose of estimating hydraulic conductivity. Appendix A contains a discussion of the purpose and problems associated with the aquifer tests in PAAs 2 and 3.

However, there are also problems associated with aquifer test performed in PAA-1. None of the observation wells were in PAA-3. Therefore, no estimates of hydraulic conductivity in PAA-3 can be derived from this test. In addition, off-mine pumping may have affected test results<sup>351</sup>. This would result in estimates of hydraulic conductivity and flow rates that are too low.

As stated in the draft report, the data used to estimate hydraulic conductivities are far from ideal, but are the best data available<sup>352</sup>. Better estimates of hydraulic conductivity could be obtained if URI conducted additional aquifer tests that were designed to estimate hydraulic conductivities in all portions of the mine.

#### Item 5, Aquifer thicknesses and hydraulic conductivities

URI states that hydraulic conductivities should be calculated by dividing location-specific transmissivities by location-specific aquifer thicknesses<sup>353</sup>. This is correct. The hydraulic conductivities derived from the PAA-1 aquifer test have been re-calculated using location-specific aquifer thicknesses. This change is reflected in appendix A, table A-3.

Note that URI does not appear to have used location-specific thicknesses in its calculations of hydraulic conductivities. Instead, it used a thickness of 205 feet in its calculations, even when the location-specific thickness was known to be substantially less<sup>354</sup>. In addition, URI did not deduct the thickness of clay zones from the total aquifer thickness. Clay zones do not contribute significant amounts of water to the well. Failure to account for the clay zones results in lower estimates of hydraulic conductivity and groundwater flow-rates.

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<sup>350</sup> The aquifer test data are used to calculate transmissivity. The transmissivity value is then used to calculate hydraulic conductivity, which is then used to calculate groundwater flow rates.

<sup>351</sup> URI, 1983(?), section 11.

<sup>352</sup> In general, the aquifer tests performed in PAAs 2 and 3 yielded lower estimates of hydraulic conductivity than did the test in PAA-1 (see appendix A, table A-1). This results in lower estimates of groundwater flow rates.

<sup>353</sup> Aquifer thickness is defined as the cumulative thickness of the sandy portions of the production zone (see appendix A).

<sup>354</sup> See URI, 1983(?), figures 10 and 13. The maximum thickness at monitor well PBL-3 is 175 feet. URI used a thickness of 205 feet to calculate the hydraulic conductivity at PBL-3.

The aquifer thicknesses used by TDH to calculate groundwater flow rates are not clearly documented<sup>355</sup>. TDH does not specify the thicknesses it used and there is no indication that it used location-specific thicknesses. However, a thickness can be estimated by back-calculation from the data that TDH does provide. This results in a thickness of 202 feet<sup>356</sup>. As with the thicknesses used by URI, this thickness does not account for clay zones and would result in estimates of hydraulic conductivity and groundwater flow-rates that are too low.

#### General note on URI's estimates of groundwater flow rates

URI has not conducted a thorough investigation of the factors that influence groundwater flow rates at the KVD Mine. A thorough investigation would include additional aquifer tests, and measurements of local and regional hydraulic gradients.

#### **URI Comment 5**

URI addresses two items in this comment:

- 1) Field filtration and preservation.
- 2) Airlifts vs. pumping.

#### Item 1, Field filtration and preservation

URI states that it does not filter and preserve samples in the field because it is cumbersome and risks contaminating the sample. They also claim that filtration takes too long, one to two hours. Finally, URI claims that the EPA does not recommend field filtration.

First, the fact that sample collection may be cumbersome is irrelevant. It must be done properly.

Second, if the proper equipment is used, field filtration and sample preservation is neither cumbersome nor excessively time consuming. In January 2006 the author collected a series of groundwater samples in southern Nevada. Approximately two gallons were collected from each well. The sample bottles were pre-cleaned by the supplier and pre-preserved<sup>357</sup>. In-line disposable filters were used. Sample water was forced through the filters by a portable peristaltic pump. The pump was powered by a portable electric drill. Filtration of the two gallons required approximately 20 minutes.

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<sup>355</sup> TBRC, 1985, pages 60 – 65.

<sup>356</sup> TDH gives an average transmissivity (T) of 16,140 gpd/ft and an average hydraulic conductivity (K) of 80 gpd/ft<sup>2</sup>. TBRC, 1985, pages 60 – 65. Then. T/K = 202 ft.

<sup>357</sup> The analytical laboratories added preservatives to the bottles before they were shipped to the field.

Third, there is little danger of contaminating samples if they are handled properly. Proper handling may require the use of shrouds (e.g., plastic bags) or filtering the sample inside a properly equipped sampling vehicle. In addition, it is a common practice to collect field/equipment blanks as a means of detecting possible sample contamination.

Finally, URI claims that the EPA does not recommend field filtration. They base this on a document produced in 1983. However, recent EPA guidelines emphatically recommend field filtration:

*“The first one-half to one liter of sample taken through the filter will not be collected, in order to assure the filter media is acclimated to the sample. If filtered samples are collected, WITHOUT EXCEPTION, filtering should be performed in the field as soon as possible after collection, and not later in a laboratory”.*<sup>358</sup>

#### Item 2, Airlifting vs. pumping

The draft report states that airlifting could oxidize the formation in the immediate vicinity of the well. But, as URI explains in its comment, airlifting is conducted a manner that makes this unlikely. Therefore, the text of the final report has been revised.

However, URI’s comment does not address the other issues raised in the draft report concerning the airlifting of groundwater samples. Those issues were the possible occlusion of contaminants, and the stripping of gasses.

URI has recommended a series of tests to compare samples collected by airlift and pump methods. These tests would be useful. They should be designed in cooperation with the CRB.

#### **URI comments 6, 7 and 8**

All of these comments concern excursions and the methods used to define them.

The discussion of excursions in the draft report is primarily a criticism of State requirements. URI did not define what constitutes an excursion, but it benefits from the State’s lax definition. Most of URI’s comments merely defend the State’s method of defining excursions. However, URI makes some statements in these comments that should be addressed.

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<sup>358</sup> EPA, 2002, page 47. Emphasis in original.

## NUREG-1569

In comment 6 URI quotes from a U.S. Nuclear Regulatory Commission document (NUREG-1569)<sup>359</sup> to support its position on upper control limits (UCLs, also called control parameter upper limits). However, URI did not include statements from NUREG-1569 that are not in agreement with its position or procedures regarding UCLs<sup>360</sup>:

- NUREG-1569 states that at least four sample sets should be collected from monitor and baseline wells<sup>361</sup>. The purpose of these sample sets is to “... *adequately evaluate spatial and temporal variations in pre-operational water quality.*” In most cases URI collected only one pre-operational (pre-mining) sample.
- NUREG-1569 recommends the use of statistical methods to deal with outliers<sup>362</sup>. URI did not consider outliers.
- NUREG-1569 recommends the use of statistical methods to establish UCLs<sup>363</sup>. This was not done at the KVD Mine<sup>364</sup>.

## False positives vs. false negatives

URI objects to the use of a statistical method for establishing UCLs (the 95% UTL method) because it may lead to false positives. However, NUREG-1569 recommends the use of statistical methods and recognizes that any method used to establish UTLs may result in false positives<sup>365</sup>. The issue is not whether false positives will occur, but their frequency.

As stated in the draft report, the 95% UTL method may result in false positives approximately 5% of the time<sup>366</sup>. That is, approximately one in twenty background (pre-mining) samples may contain constituent concentrations that are above the level defined as an excursion. In the data set used to establish the

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<sup>359</sup> NRC, 2003.

<sup>360</sup> In fairness to URI it should be noted that they did not mention the fact that NUREG-1569 supports their position on the screening of monitor wells (NRC, 2003, 5.7.8.3 (3)).

<sup>361</sup> NRC, 2003. 5.7.8.3 (1).

<sup>362</sup> NRC, 2003. 5.7.8.3 (1). An outlier is an unusually high or low value for a single well. The issue of unusually high values is discussed in sections 5.1 and 5.2.

<sup>363</sup> NRC, 2003. 5.7.8.3 (2). The use of statistics to establish UCLs is discussed in the section 5.2.

<sup>364</sup> NUREG-1569 states: “*In some cases, the use of a simple percentage increase above baseline values is acceptable.*” This method was used to establish the UCLs for EC and chloride at the KVD Mine (see section 5.1). However, this method appears to apply to areas with good water quality (TDS < 500 mg/L, NRC, 2003, 5.7.8.3 (2)). Water quality at the KVD Mine is generally poor (see section 4.1).

<sup>365</sup> NRC, 2003, 5.7.8.3 (2).

<sup>366</sup> See section 5.2.

95% UTLs for the KVD Mine, 3 of 116 pre-mining samples were defined to be excursions (< 3%)<sup>367</sup>.

URI makes much of the problems associated with false positives. However, between 1988 and 2005 the UTL method identified 25 post-mining excursions at 15 wells, including the two acknowledged by URI<sup>368</sup>. This is an average of less than two per year.

URI does not directly address the issue of undetected excursions, or false negatives. However, the State's method sets the UTLs too high. This results in false negatives and excursions at the KVD Mine have gone undetected<sup>369</sup>. It is better to detect a possible excursion and investigate it<sup>370</sup>, than to ignore an excursion and allow it to go uncorrected.

#### Over-confidence in model results, contaminant transport mechanisms

In the last two paragraphs of comment 8, URI states the following:

*"... an ISR wellfield pattern is surrounded by flair as water travels in a radial pattern from injection to extractor (See attachment for an illustration of radial flow of path lines in a wellfield). ..."*

*"Because groundwater flows radially and the wellfields are subjected to a production bleed, it would be hard to even hypothesize a scenario where an excursion of leach solution would present itself in a monitor well for a period of time and then just go away. ..."*

*"It is impossible for the excursion to go uncorrected, and the wellfield imbalance to continue because continuous radial flow of leach solution would increasingly impact the well, and succeeding samples from that well would show increasing levels of lixiviant contaminants. Since no increasing trend was recorded in those wells, it is evident that no excursion occurred."*

There are several problems associated with these statements.

1. URI appears to be an over-confident in the results of its modeling. URI's modeling predicts that all flow is radial and all contaminants will eventually be removed by extraction wells. It should not be necessary to say that, at best, the predictions produced by models are only approximations of what may occur. Sometimes the predictions are misleading. URI's model does

<sup>367</sup> See appendix C. Even though false positives may occur using any method of defining excursions, this is not an insoluble problem. UCLs may be defined for individual wells rather than for the aggregation of all wells in a PAA (NRC, 2003, 5.7.8.3 (2)).

<sup>368</sup> See table 5.2-2; and URI, 2005I.

<sup>369</sup> See section 5.2.

<sup>370</sup> URI presents a list of factors to consider in comment 8.

not appear to have predicted the excursions that it acknowledges (i.e., at MW-49A and MW-172)<sup>371</sup>.

2. The excursions that occurred at the KVD Mine probably represent mining solutions that have escaped the influence of the extraction wells. Therefore, they no longer follow the radial flow paths predicted by the model. Instead, they are transported along gradients that force them through the ring of monitor wells that surround the production areas.

To believe otherwise would require the mining solutions to follow radial flow paths that take them beyond the ring of monitor wells at one point, and then bring them back into the ring at another point. This seems far less likely than the explanation presented above.

3. It is common for contaminants to be present '*in a monitor well for a period of time and then just go away.*' This is the behavior associated with non-continuous (intermittent) sources of contaminants. The figures reproduced below illustrate this behavior<sup>372</sup>. It is not difficult to hypothesize how this could occur during mining at the KVD Mine as the rates and locations of injection and pumping were changed<sup>373</sup>.

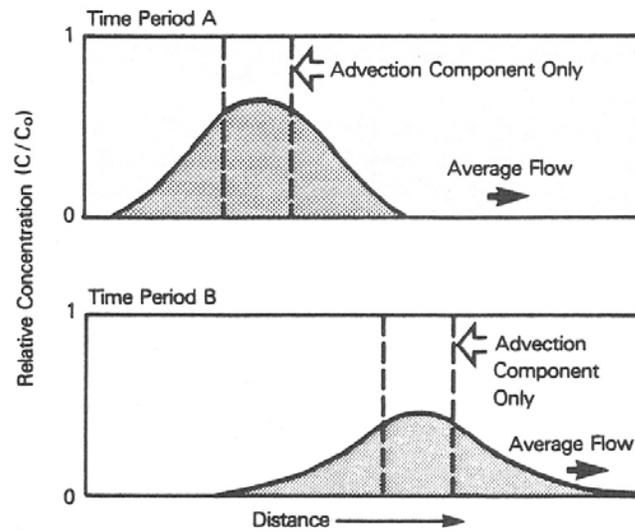
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<sup>371</sup> See section 5.1.

<sup>372</sup> Barcelona et al., page 13.

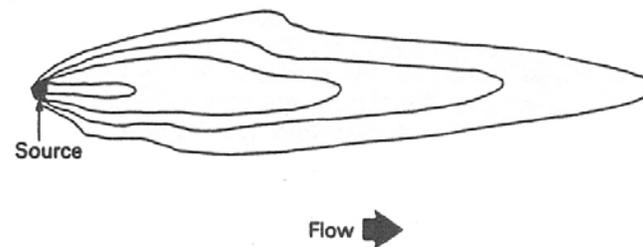
<sup>373</sup> URI, 2005b.

**Figure 1-12** Movement of a dissolved constituent slug by advection and dispersion as it moves from time period (a) to (b).



**Figure 1-13** Continuous and intermittent sources affected by dispersion.

A. The development of a contamination plume from a continuous point source.



B. The travel of a contaminant slug(s) from a one-time point source or an intermittent source.



## URI Comment 9

### Effects of mining on domestic wells

URI did not comment on this issue.

## URI Comment 10

This comment concerns 'supplementary baseline wells'. URI defines supplementary baseline wells as follows: *"Every extraction well in a new wellfield that gets a pump and is sampled before injection begins."*<sup>374</sup>

URI states that it may use data from supplementary wells pursuant to 30TAC §331(f). These are the State rules regarding production area development and restoration for in-situ mines. They cover the following topics:

- Applicability
- Confinement of Mining Solution
- Production Area Monitor Wells
- Establishment of Baseline and Restoration Values
- Monitoring Standards
- Remedial Action for Excursion
- Restoration

URI may use data from the supplementary wells to expand the number of baseline wells at each PAA<sup>375</sup>. This could have the effect of raising the allowable restoration standards. For example, the current State restoration requirement for uranium in PAA-1 is 0.164 mg/L. This is close to the average pre-mining concentration for the current baseline wells (0.166 mg/L)<sup>376</sup>. However, if the list of baseline wells was expanded to include the supplemental baseline wells at PAA-1, the average pre-mining uranium concentration would be approximately 2.6 mg/L<sup>377</sup>. URI might then ask the State to raise the restoration requirement to the new average.

Some supplementary wells may be suitable to use as baseline wells, and some may not because they may have been affected by mining solutions before they were sampled<sup>378</sup>. If URI wants to use any of these wells, they should be required to show that their use is appropriate.

## URI Comment 11

This comment describes the process URI would have to follow if it wanted the State to relax restoration requirements at the KVD Mine. URI also states that if it decides to ask the State to relax restoration requirements, it would first bring the request and associated documentation to the Citizen's Review Board.

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<sup>374</sup> Personal communication from Mark Pelizza of URI, June 20, 2006.

<sup>375</sup> Personal communication from Mark Pelizza of URI, June 20, 2006.

<sup>376</sup> See Table 7.4-1.

<sup>377</sup> This assumes the supplementary wells are the 4000-series and 7000-series wells. These are the supplementary wells that URI claims are associated with PAA-1 (URI comment 15). However, the 4000-series wells are in PAA-2, not PAA-1.

<sup>378</sup> See section 7.1.1.

## URI Comment 12

This comment discusses the justification for relaxing State restoration requirements. URI makes the following points:

1. Some of the parameters that fail to meet existing requirements (calcium, sulfate, molybdenum, pH) are not harmful to human health.
2. Prior to mining, groundwater in the mine zone was not suitable for use as a source of drinking, irrigation, or livestock water<sup>379</sup>.
3. Continued restoration efforts would consume energy, water, and other natural resources without providing a corresponding benefit.

The relaxed requirements might not be a problem if all of the contaminated water remained within the mine boundaries after restoration ceases. However, as explained in section 7.5, there is no guarantee that the water will not migrate beyond the mine's boundaries. Therefore, if post-restoration concentrations remain above baseline levels and EPA drinking water standards, URI should be required to establish a long term monitoring program to detect contaminated groundwater that may move beyond the mine boundaries. URI should also be prepared to remediate any contaminated groundwater that may move beyond the boundaries.

### Item 1, Some contaminants not harmful to health

This is correct, although these constituents contribute to TDS and can affect the aesthetic qualities of water. On the other hand, some of the contaminants are harmful to health: uranium and radium.

### Item 2, Pre-mining groundwater not suitable for use

The pre-mining analyses of baseline wells showed that all but one well was unsuitable for use as a source of drinking, irrigation, or livestock water. The exception was well I-11<sup>380</sup>.

However, URI did not sample any of the baseline wells for radon-222 prior to mining. As stated in the response to URI's comment 1, it is likely that the pre-mining concentrations of radon-222 were high. Concentrations probably exceeded the EPA primary drinking water standard of 300 pCi/L at most locations near the ore bodies.

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<sup>379</sup> Mining, however has caused an increase in the concentrations of contaminants. For example, prior to mining, the average uranium concentration in baseline wells at PAA-1 was 0.164 mg/L. Now it is about five times higher: 0.961 mg/L (see table 7.2.1-1). Both levels exceed the drinking water standard of 0.030 mg/L.

<sup>380</sup> See section 7.3.5.1.

This raises a question regarding well I-11. Did the pre-mining radon-222 concentration exceed the primary drinking water standard at well I-11? This is possible. However, the pre-mining concentrations of uranium and radium-226 at I-11 were well below the drinking water standard (0.008 mg/L and 0.66 pCi/L respectively)<sup>381</sup>. Therefore, it is possible that the pre-mining concentration of radon-222 was also below the standard.

Item 3, Continued restoration efforts consume resources without corresponding benefit

This may be correct. However, URI has not presented a thorough analysis of the costs and benefits of continued restoration. Therefore, a fully informed judgment cannot be made.

**URI Comment 13**

This comment concerns URI's failure to satisfy its agreement with the County to pump and treat at least 240 million gallons in 2005.

URI claims it has satisfied its agreement with the County because the shortfall was caused by the failure of a pump – a 'Force Majeure'.

The following definition of force majeure is from Yale University's on-line library<sup>382</sup>:

*"Force Majeure literally means "greater force". These clauses excuse a party from liability if some unforeseen event beyond the control of that party prevents it from performing its obligations under the contract. Typically, force majeure clauses cover natural disasters or other "Acts of God", war, or the failure of third parties--such as suppliers and subcontractors--to perform their obligations to the contracting party. It is important to remember that force majeure clauses are intended to excuse a party only if the failure to perform could not be avoided by the exercise of due care by that party."*

The pump failure does not seem to constitute a force majeure.

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<sup>381</sup> This is the lowest pre-mining uranium concentration and second lowest pre-mining radium-226 concentration found in any baseline well (see sections 7.3.5.1 – 7.3.5.5). Like radon-222, radium-226 is a decay product of uranium.

<sup>382</sup> <http://www.library.yale.edu/~llicense/forcegen.shtml>

### URI Comment 14

This comment concerns the restoration of well I-11. Under its agreement with the County, URI is required to restore this well so it is suitable for use as a source of drinking, irrigation, and livestock water<sup>383</sup>.

URI states that it may use reductants or bacteria to restore the well. However, the effectiveness of the reductants may decline over time<sup>384</sup>. Therefore, long-term monitoring should be required before the restoration is declared to be complete.

### URI Comment 15

This comment concerns the elevated concentrations of uranium and molybdenum in PAAs 1 and 2.

URI makes the following claims:

1. Pre-mining concentrations of uranium and molybdenum in PAA-1 were actually higher than the concentrations measured in the baseline wells. URI bases this claim on data from 'supplementary baseline wells'. The supplementary wells contained higher concentrations of these metals than did the original baseline wells.
2. In all cases, pre-mining uranium concentrations at PAA-1 exceeded drinking, livestock, and irrigation use standards by a significant margin.

URI also poses a question. Will uranium and molybdenum in groundwater migrate outside the license area, or will the natural reducing capacity of the groundwater cause these metals to remain in place? URI then states that, over time, the groundwater in the ore zone will return to its pre-mining redox state.

#### Item 1, Pre-mining uranium and molybdenum, and supplementary baseline wells

There are problems with the supplementary baseline wells listed in this comment.

First, in the table accompanying comment 15 URI shows the 4000-series wells as being in PAA-1. This is incorrect. All of the 4000-series wells are in PAA-2<sup>385</sup>.

Second, some of the chemical analyses are inconsistent. For example, there are two analyses for supplementary well 7512. Both analyses are for a sample

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<sup>383</sup> See section 7.3.5.1.

<sup>384</sup> See section 7.5.

<sup>385</sup> URI, 2005u.

collected on 9/24/97 at 3:20 pm<sup>386</sup>. In one analysis, the concentrations of uranium and molybdenum are given as 1.86 mg/L and 2.2 mg/L, respectively. In the other analysis, the concentrations of uranium and molybdenum are given as 0.248 mg/L and 1.7 mg/L, respectively. This raises the question, what are the baseline concentrations at supplementary well 7512? In addition, the 'baseline' concentrations of chloride and sulfate are quite high at well 7512 (708 mg/L and 1580 mg/L, respectively)<sup>387</sup>. These high values suggest that well 7512 may have been affected by mining solutions before the baseline sample was collected.

As stated in the response to comment 10, the use of data from supplementary wells may be appropriate in some cases and not in others. If URI proposes to use data from any of the supplementary wells, it should be required to show that the use of the data is appropriate. This showing should be required for the data from each well that URI wishes to use.

### Item 2, Pre-mining uranium concentrations

This is incorrect. Five out of 15 PAA-1 baseline wells had pre-mining uranium concentrations that were less than the drinking water standard<sup>388</sup>. These are wells I-1, I-3, I-10, I-11, and I-12<sup>389</sup>.

Finally, the question that URI poses is a good one. Unfortunately, we don't know the answer. It is possible that, over time, the groundwater will return to its pre-mining redox state. However, we don't know how much time would be required.

### **URI Comment 16**

This comment concerns the fate of the contaminants that will remain after restoration ends.

URI makes the following claims:

1. Dispersion and geochemical attenuation make it highly unlikely that contaminants will migrate beyond the mine area.
2. Long-term monitoring is not practical.
3. URI will conduct additional analyses to demonstrate that the downgradient transport of contaminants will be limited by dilution and geochemical attenuation.

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<sup>386</sup> The chemical analyses were performed on different dates. (URI 1987a, section titled *Ground Water Analysis Reports (All Baseline and Monitor Wells)*).

<sup>387</sup> URI 1987a, section titled *Ground Water Analysis Reports (All Baseline and Monitor Wells)*.

<sup>388</sup> The drinking water standard for uranium is 0.03 mg/L (see table 7.3.5-1).

<sup>389</sup> See table 7.3.5.1-1.

4. The portion of the aquifer that was oxidized as a result of mining will return to its original, reduced state. As a result, redox-sensitive metals such as uranium will be precipitated.

#### Item 1, Dispersion, geochemical attenuation, and migration

This is possible. However, it is equally possible that contaminants will migrate beyond the mine area. URI has not collected any data regarding dispersion or other attenuation mechanisms at the KVD Mine. URI claims to have measured the redox potential at the mine, but to have discarded the data<sup>390</sup>. URI's optimistic predictions are based on hydraulic and geochemical properties that they haven't measured.

#### Item 2, Long-term monitoring not practical

URI does not give any information to support this claim.

#### Item 3, URI will conduct analyses to demonstrate that migration will be limited

Presumably, such analyses will rely on the use of computerized models. Models can be used to predict future conditions. If the modeling is done properly, their results may approximate future conditions and may be used to design more effective and efficient restoration and monitoring systems. On the other hand, the modeling results may be little more than techno-nonsense.

For a modeling project to yield realistic results, the entity performing the modeling must have 1) skilled personnel, and 2) the site-specific data required to conduct realistic simulations<sup>391</sup>. URI may have access to skilled personnel, but they do not have the site-specific data.

However, even if modeling efforts are properly conducted, their results cannot replace real data. As stated above, models may be used to design monitoring systems, but they cannot replace monitoring.

#### Item 4, Reducing conditions will be re-established and redox-sensitive metals will be precipitated

This is the essentially the same issue discussed in comment 2. A slightly modified version of the response to comment 2 is repeated here.

Reducing conditions may be re-established. However, the re-establishment, if it occurs, may take a long time.

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<sup>390</sup> See section 7.5.

<sup>391</sup> This includes hydraulic data (e.g., groundwater velocities and dispersivities) and geochemical data (e.g., redox potentials and partition coefficients).

There is little if any indication that reducing conditions are being re-established at the KVD mine. It has been more than five years since mining ceased in PAAs 1 and 2. Concentrations of uranium, molybdenum, and sulfate remain well above their baseline levels. Radium-226 concentrations also remain elevated<sup>392</sup>.

If they are not cleaned up, the remaining contaminants pose a risk to nearby groundwater resources. After restoration ceases they may be transported beyond the mine boundaries<sup>393</sup>.

### **URI Recommendation 1**

Recommendation to increase analyses of radon-222 in water near the KVD mine and notify property owners if concentrations of uranium, radon-222, or radium-226 exceed standards.

Agree with recommendation. However, the issue of who notifies property owners will have to be determined by URI and the Citizen Review Board (CRB).

### **URI Recommendation 2**

Recommendation to conduct tests to compare samples collected by airlift and pump methods.

Agree with recommendation. Tests should be designed by URI and CRB.

### **URI Recommendation 3**

Recommendation to perform modeling to estimate effects of dispersion on contaminant concentrations.

Agree with recommendation. However, to be meaningful, the modeling must be conducted using the necessary site-specific data. In this case, that includes hydraulic conductivities, hydraulic gradients, porosities, and dispersivities (see recommendation 5, below). Finally, it must be remembered that modeling results are only approximations. They cannot replace real data obtained through monitoring.

### **URI Recommendation 4**

Recommendation to measure redox potential in vicinity of KVD mine and use results in a geochemical model to predict attenuation of contaminants.

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<sup>392</sup> Compare values in tables 7.3.5.1-1 and 7.3.5.2-1 with the values in appendix F. Note: the re-establishment of reducing conditions will not decrease radium-226 concentrations (Demuth and Schramke, 2006, page ii).

<sup>393</sup> See section 7.5.

Agree with recommendation. Measurement plan should be designed by URI and CRB. However, as stated above, modeling results cannot replace monitoring.

#### **URI Recommendation 5**

Recommendation to perform tracer tests to assess the potential for the transport of contaminants by groundwater.

Agree with recommendation. Tests should be designed by URI and CRB. It is assumed that the tests will measure the properties that control the fate and transport of contaminants (e.g., dispersivities, retardation coefficients).

#### **URI Recommendation 6**

Recommendation to evaluate the feasibility of reducing oxygen concentrations in injected water by installing a 'nitrogen blanket' or an oxygen scavenging system.

Agree with recommendation.

#### **URI Recommendation 7**

Recommendation to consider use of hydrogen sulfide or other reductant to restore groundwater in vicinity of well I-11.

Agree with recommendation. However, the effectiveness of the reductants may decline over time<sup>394</sup>. Therefore, long-term monitoring should be required before the restoration is declared to be complete.

#### **Note on the report by Hal Demuth and Janet Schramke, *Fate and Transport of Post-Restoration Groundwater Constituents at In-Situ Uranium Leach Facilities***

This report is appended to URI's comments. It describes the physical and geochemical processes that control the migration of groundwater contaminants after restoration is completed at in-situ uranium mines. URI has incorporated some of this report's statements and conclusions into its comments<sup>395</sup>. The responses to those comments will not be repeated here.

The report contains a good overview of contaminant transport processes associated with in-situ uranium mining. However, some of the statements that specifically refer to the KVD Mine are merely repetitions of URI's position and

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<sup>394</sup> See section 7.5.

<sup>395</sup> Compare, for example, claims 1 and 4 of comment 16 with the last paragraph on page iii of the Demuth and Schramke report.

should be taken with a grain of salt<sup>396</sup>. Some of the statements regarding modeling should also be viewed with some skepticism<sup>397</sup>. Unless a model's predictions are confirmed by field data, they should be viewed as indications of what might happen, not what will happen.

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<sup>396</sup> For example, the statements regarding groundwater velocity on page 15. Note: in the first paragraph of page 15, Demuth and Schramke appear to confuse hydraulic conductivity and permeability. They state that hydraulic conductivity is independent of viscosity and density. This is incorrect. Permeability is independent of these parameters, but not hydraulic conductivity (Freeze and Cherry, 1979, page 27).

<sup>397</sup> Demuth and Schramke, 2006, pages 16, 17, and 38, for example.