SAFETY EVALUATION REPORT
ALTERNATE CONCENTRATION LIMITS
ANADARKO PETROLEUM CORPORATION
BEAR CREEK URANIUM MILL SITE
CONVERSE COUNTY, WYOMING

DOCKET NO.: 40-8452

LICENSE NO.: SUA-1310

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FACILITY: Bear Creek Site, Wyoming

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1.0 SUMMARY AND CONCLUSIONS

Anadako Petroleum Corporation (the Licensee) wants to amend its License for the Bear Creek Uranium Corporation (BCUC) mill site to delete its well sampling requirements in order to facilitate transfer of the site to the U.S. Department of Energy (DOE) for long-term care and surveillance. The process of transferring the License to DOE was started in 1997 with an alternate concentration limit (ACL) proposal by BCUC. ACLs for nickel, radium and uranium at the Point of Compliance (POC) wells were approved and incorporated into BCUC's License by Amendment No. 35. BCUC then submitted a reclamation report in 2000 and the U.S. Nuclear Regulatory Commission (NRC) agreed that reclamation was complete. Subsequently, in 2002, DOE submitted a draft Long-Term Surveillance Plan (LTSP) which was approved by NRC. However, BCUC was unable to purchase the subsurface estate associated with the Bear Creek operation which remained in State of Wyoming ownership and the site could not be transferred to DOE as planned (NRC, 2003).

In 2009, DOE again submitted a draft LTSP with the anticipation that the State would allow the transfer of the land. DOE is now the legal owner of the land but the License has not been transferred. In 2010, in preparation for License termination and transfer to DOE, NRC reviewed the ground water data for the time period from 1997 to 2010 and found that uranium concentrations had exceeded the predicted concentration at one of the Point of Exposure (POE) wells showing that the 1997 model was incorrect. Consequently, NRC requested that new ACLs be proposed even though the 1997 ACLs at the POC wells were not exceeded. The Licensee submitted its new ACL proposal on November 28, 2011. The proposed ACLs are the same as the 1997 ACLs; however, the ground water model supporting the ACLs has been revised and the POE concentration predictions have been changed due to this revised model and due to the POE wells being moved further from the tailings disposal cell. The revised ground water model predicts, as did the 1997 model, that, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 40, Appendix A, 5B(5), the concentration of hazardous constituents will not exceed the ACLs at the POC wells.

The purpose of this SER is to evaluate the ACLs in light of the revised ground water model and the moved POE wells to determine whether the applicable requirements in 10 CFR Part 40, Appendix A, "Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily for their Source Material Content," are satisfied and, thus, whether the well sampling requirements of the License can be deleted. According to 10 CFR Part 40, Appendix A, 5B(6), the NRC will establish proposed ACLs for hazardous constituents if it finds that the proposed limits are as low as reasonably achievable (ALARA) and that the constituents will not pose a substantial present or potential hazard to human health or the environment as long as the ACLs are not exceeded. According to 10 CFR Part 40, Appendix A, 5B(5), the concentration of hazardous constituents must not exceed the ACLs at the point of compliance. The ACLs at issue were previously found in 1997 to have satisfied both of these requirements and the following SER demonstrates that this finding remains valid. Since the ACLs still satisfy 10 CFR Part 40, Appendix A, 5B(6) and since the ACLs will still not be exceeded at the POC, in satisfaction of 10 CFR Part 40, Appendix A, 5B(5), the ACLs are still sufficient. Additionally, with this verification of the ACL sufficiency, the License's well sampling requirement may be deleted and the Licensee may proceed to transfer the License to DOE. According to 10 CFR Part 40, Appendix A, Criterion 11, prior to termination of a milling or tailings license, the licensee must transfer the title to byproduct material and land which is used for the disposal of any such byproduct material to the United States or the State in which such land is located. This transfer must be accomplished without cost to the United States or the relevant State. Since the ACLs have been verified and since their non-exceedence at the POC has been verified, the License may be amended to delete the Licensee's well sampling requirement and, since such a transfer would be without cost, the Licensee may transfer the License to DOE. Though no further ground water monitoring is required to prevent substantial hazard to human health or the environment, the NRC recommends that DOE conduct limited monitoring in order to verify the predictive accuracy of the revised ground water model. Since this monitoring results in cost to the United States, the Licensee must provide sufficient surety to cover this cost.

2.0 BACKGROUND

2.1 Proposed Actions

The Licensee wants to eliminate LC No. 47 which requires the Licensee to sample wells annually and report the results to NRC. LC No. 47 states:

The Licensee shall implement a groundwater compliance monitoring program containing the following:

A. Sample Well Nos. MW-9, MW-12, MW-14, MW-43, and MW-74 on an annual frequency for nickel, combined radium-226 and -228, selenium, thorium-230, and uranium. Sample Well Nos. MW-12 and MW-74 on an annual frequency for beryllium, cadmium, chromium, and molybdenum. Sample Well Nos. MW-108, MW-109, MW-110, and MW-111 on an annual frequency for nickel, combined radium- 226 and -228, thorium-230, uranium, chloride, and sulfate.
B. Comply with the following groundwater protection standards at point of compliance (POC) Well Nos. MW-12 and MW-74, with background water quality established in Well No. MW-9: beryllium = 0.01 mg/L, cadmium = 0.01 mg/L, chromium = 0.05 mg/L,

molybdenum = 0.02 mg/L, selenium = 0.025 mg/L, thorium-230 = 2.6 pCi/L, nickel = 3.8 mg/L, combined radium-226 and -228 = 46 pCi/L, and uranium = 2038 pCi/L.

C. In the event the limits for the constituents in Subsection (B) are exceeded, the Licensee will propose a new corrective action program with the objective of returning concentrations of those constituents to the concentration limits specified in Subsection (B).

The other proposed actions are to retain the ACLs established in 1997 at the two POC wells for nickel, radium-226 and -228, and uranium and to establish new POE wells at the northern boundary of the site. The Licensee will also establish Institutional Controls (ICs) restricting domestic, livestock and agricultural ground water use within the long term surveillance boundary (LTSB). Thus, the construction of ground water supply wells and residences on the disposal site property will be precluded in perpetuity. These restrictions will be accomplished through federal ownership of the property. All of these actions are proposed to facilitate the ultimate transfer of the License from the Licensee to DOE.

2.2 Bear Creek Mill Operations

The Bear Creek Mill that produced the uranium mill tailings at issue was owned and operated by Bear Creek Uranium Company. Bear Creek Uranium Company was a joint venture of Southern California Edison and Rocky Mountain Energy. Rocky Mountain Energy was the operating partner. Company reorganization had made Rocky Mountain Energy part of Union Pacific Resources (UPR 1999). In 2000 Anadarko Petroleum Corporation acquired Union Pacific Resources.

Milling commenced in the summer of 1977 and continued until January 20, 1986. The ore processed in the Bear Creek mill came from several open pit mining operations in the immediate vicinity of the mill site. The milling process consisted of sulfuric acid leach, sodium chlorate oxidant, and liquid ion exchange extraction and concentration. As a result of these operations, approximately 4.7 million tons of uranium mill tailings were produced and discharged into the tailings basin as a slurry. After 1986, an interim cover and three evaporation ponds were constructed on top of the mill tailings area. The evaporation ponds were part of a ground water corrective action program (CAP) which was in place from 1986 to 1996. The mill and solvent extraction buildings were decommissioned in 1988.

2.3 Final Surface Conditions

The final surface conditions at the BCUC site are a combination of rock armoring, contouring, and re-vegetation to achieve the necessary surface water run on and run off control and erosion protection to satisfy the longevity design requirements. The re-vegetated surfaces have been planted with a mix of prairie grasses that have proven to be successful in reclaiming nearby surface mine areas and will help provide soil stability (DOE, 2002).

A combination of a compacted soil ridge, drainage swales, and diversion channels convey incident surface water away from the tailings disposal cell. Critical portions of the diversion channel where design basis flow velocities could cause erosion are riprap armored. In particular the chute area is armored with riprap and the final discharge point of the diversion channel is a riprap-armored weir that functions as a check dam. The steeper face of the tailings impoundment dam and several dam face discharge points also are armored with riprap. The

tailings area itself occupies 101 acres of the 1,000-acre disposal site property (DOE, 2002).

3.0 TECHNICAL EVALUATION

3.1 Geology and Hydrogeology

3.1.1 Geology

The Powder River Basin is the regional geologic and physiographic structure. The basin lies between the Black Hills on the east, the Bighorn Mountains on the west, the Laramie Mountains, the Hartville uplift, and the Powder River lineament on the south. At the BCUC site the lower part of the Wasatch Formation (Wasatch) of Eocene age is the bedrock (DOE, 2002).

The Wasatch is about 400 feet thick at the site. Ground water occurs in the Wasatch under both confined and unconfined conditions. The Wasatch is underlain by the Fort Union Formation. The Fort Union Formation is about 2,800 feet thick in the vicinity of the BCUC site. Ground water in the Fort Union Formation is confined (NRC, 1977).

Most of the uranium produced at the Bear Creek mill was mined from deposits in the Wasatch 100 to 200 feet below the surface. Most of the known uranium ore deposits in the area occur in the Fort Union and Wasatch Formations (NRC, 1977).

3.1.2 Hydrogeology

Three sandstone layers of importance in the upper portion of the Wasatch at the BCUC site include, from shallower to deeper, the K Sand, the N Sand, and the Ore Sand. The Ore Sand is separated from the shallower sands by claystones and siltstones. Hydro geologic and water quality data collected throughout the area during the BCUC operations indicates this material is an effective aquitard (i.e., layer of low permeability). In addition, there are no indications that mining activities have created communication through the aquitard in the potential area of impact of the tailings (WDEQ, 1999).

The uppermost saturated zone is found within 40 feet of the original ground surface and is referred to as the N-sand. The flow direction in the N-sand is in a north to northeast direction. As a result, the low pH tailings solution that has seeped from the tailings impoundment into the N-sand has migrated in a north to northeast direction. There is no history of this upper saturated zone of the Wasatch formation being used for a domestic or livestock water supply in this region of the Powder River Basin in Wyoming. The estimated well yield for N-sand monitor wells MW-108 and MW-109 is <0.01 gallons per minute which would not be sufficient for daily residential or livestock use (See Site Map for location of monitoring wells).

There are several existing stock water wells completed to 430 to 515 foot depths, in which the water bearing formations are separated from the N-sand by hundreds of feet of low permeable claystone (i.e., aquitard), located within a mile or less of the proposed POE locations on Lang Draw and the Northern flow path. The wells GW-8, GW-10 and GW- 15 are located <1/2 mile south-west of the proposed new POE on Lang Draw, <1 mile north of both Lang Draw and the Northern flow path, and 1 mile north-west of the Lang Draw flow path proposed new POE, respectively. These wells provide water at 2-3 gallons per minute, which is utilized for livestock. All three are windmill driven and have been sampled in the past for groundwater parameters.

Water samples were collected from these wells and reported to the Wyoming Department of Environmental Quality (WDEQ) in required annual reports during operation of the mine. These wells do not appear to have been impacted from the former uranium mill operations.

In 1997, boreholes were drilled by S.M. Stoller (Stoller, 1997) north of the 1997 POEs located near Lang Draw (MW-14) and the Northern flow path (MW-43) and south of the Anadarko property boundary. Significant water was not encountered in any of the boreholes along Lang Draw at the time of drilling. Only boreholes near MW-108 in Lang Draw were found to contain wet sands. It was Stoller's opinion that "…it is very unlikely that the alluvium will produce enough water to satisfy the NRC definition of an aquifer." Two wells, drilled north of the proposed POEs (MW-109 and MW-111), designated Manning B.C.18 (GW-18, Permit No. U.W. 64632 completed Aug. 1983) and Hardy No. 4 (Permit No. U.W. 1365 drilled 1947), which were completed to depths of 432 feet and 443 feet respectively, show no water present in the N-sand in the well logs (State of Wyoming, 2012). Both wells are located north of the proposed POEs in Section 9, T 38N, R 73 W. These drilling results were independently verified by NRC staff. The NRC staff concluded that there is no viable aquifer at the site.

4.0 GROUND WATER MONITORING PROGRAM

4.1 History of Monitoring at BCUC Site

Seepage from the tailings impoundment was first observed in 1978. Several monitoring wells were installed to investigate the potential for ground water contamination migration. Sampling results indicated elevated chloride, a common mill tailings seepage indicator. In October 1979, several wells were installed for recovering tailings seepage. The effluent from these wells was pumped back into the tailings impoundment (UPR, 1997).

License Amendment No. 15, dated September 9, 1987, established background levels for “Indicator Parameters” at the BCUC site. Prior to this licensing action, NRC consulted with BCUC on the selection of an appropriate location to determine background ground water quality. It was apparent that, although the formations that underlie the tailings impoundment are found up gradient of the tailings, they thin significantly and are not saturated. Given these subsurface conditions, alternate locations representative of background water quality were reviewed. Ultimately, well MW-9 was identified as a suitable background location, as it was located downgradient of the tailings impoundment and was completed in a sandstone that is representative of the ground water quality of the site. Although well MW-9 was located downgradient of the tailings impoundment, water quality results from the well indicated no influence from mill tailings seepage at the time (UPR, 1995).

In 1995, the Licensee requested that License Condition No. 47(B) be revised as follows (UPR, 1995):

47(B). Comply with the following ground water protection standards at point of compliance well Nos. MW-12 and MW-74, with background being recognized in well No. MW-9:

> beryllium = 0.01 mg/L, cadmium = 0.01 mg/L, chromium = 0.05 mg/L, molybdenum = 0.02 mg/L, nickel = 0.05 mg/L, radium-226 and 228 = 9.7 pCi/L, selenium = 0.21 mg/L, thorium-230 = 2.6 pCi/L, and uranium = 98.7 pCi/L.

The ground water CAP began in 1986. The CAP was designed to recover contaminated ground water and control and minimize the spread of the mill tailings seepage. From CAP inception through 1996, approximately 301,000,000 gallons of mill tailings seepage water was recovered and pumped back into the tailings pond (UPR, 1997).

Results of characterization and monitoring efforts indicated there were two flow paths associated with leakage from the tailings impoundment: Lang Draw and the Northern Flow Path. The flow paths resulted in the seepage plume having two narrow lobes. The lobes eventually merge 3,000 feet down gradient of the tailings impoundment (UPR, 1997).

4.2 1997 ACL Application

The CAP successfully lowered hazardous constituent levels in the ground water, with the exception of uranium, to below the License-established background standards as measured at the POC locations. The CAP operated for over 10 years. The 1997 ACL Application (UPR, 1997) provided discussion that demonstrated that the concentrations of hazardous constituents achieved by the CAP were as low as reasonably achievable (ALARA). In response to this application, the NRC found that the proposed ACLs were indeed ALARA and that the constituents would not pose a substantial present or potential hazard to human health or the environment as long as the proposed ACLs were not exceeded at the POC wells. Therefore, the NRC approved the proposed ACLs at the POC wells and amended the License as follows (NRC, 1997):

Uranium	from 98.7 to 2038 pCi/L
Radium	from 9.7 to 46 pCi/L
Nickel	from 0.05 to 3.8 mg/L

The revised License also contained the following water quality conditions at the POE wells, MW-14 along the Lang Draw, and MW-43, along the Northern Flow Path: nickel = 0.055 mg/L and combined radium-226 and -228 = 13 pCi/L. The background concentration for uranium of 98.7 pCi/L must also be met at these two POE wells.

4.3 Concerns of WDEQ-LQD with 1997 ACL Application

The Land Quality Division (LQD) of the Wyoming Department of Environmental Quality (WDEQ) reviewed the 1997 application for ACLs and expressed its concerns in a letter to the Licensee (WDEQ, 1999). Based on its review, the LQD concurred with the NRC's and BCUC's determination that no additional active restoration of the ground water in the vicinity of the mill tailings was necessary at that time, although LQD's basis for this determination differed somewhat from that of the NRC and BCUC. LQD's primary considerations in this determination were the importance of ground water in the State and the potential for access to the contaminated ground water. LQD preferred that the ground water within the Long-Term Care Boundary be returned to pre-mining and milling conditions. However, the LQD also recognized that access to the BCUC site would be restricted, i.e., the LQD believed the federal institutional controls that would be in place when the site was transferred to the DOE were sufficient to prevent access to the contaminated ground water within the Long-Term Care Boundary. However, the presence of contaminated ground water within the Long-Term Care Boundary led to two additional concerns.

The first of these concerns was the potential for contaminated ground water to migrate outside the Long-Term Care Boundary. The second was the potential for a change in conditions along the perimeter of the boundary which could induce migration of contaminated ground water outside of the boundary. The LQD believed four safeguards were necessary to ensure that contaminant movement does not extend outside the boundary. The first safeguard was incorporating additional area into the Long-Term Care Boundary, specifically the area of Section 9 currently owned by Bear Creek, to the north of the Long-Term Care Boundary proposed in the 1997 ACL application. This additional area would provide a "buffer" for continued geochemical attenuation by calcium carbonate within the aquifer materials and a margin of error if some of the predictions prove incorrect. The second safeguard was for ground water monitoring along the two flow paths, preferably in at least two locations along each flow path, as well as monitoring the endpoints. This monitoring would provide information to evaluate the accuracy of the predicted contaminant movement. The third safeguard was to include analyses of conservative parameters such as sulfate and chloride, as well as parameters that should be attenuated in the aquifer. This would allow for evaluation of alternatives if it later appears that concentrations of parameters of concern to the State, as well as those of concern to NRC, would be exceeded. The fourth safeguard was for a periodic check, such as once every ten years, of the State Engineer's Office (SEO) records to evaluate the changes in water demands in the vicinity of the site. At present, this information can be readily obtained by submitting the location of interest to the SEO. This periodic check will help determine if any new demands on the local aquifers are of concern.

The comments from LQD on the 1997 ACL application led to the extension of the Long-Term Care Boundary approximately 1400 feet to the north and to the installation of monitoring wells MW-108 and MW-109 along the Lang Draw and MW-110 and MW-111 along the Northern Flow Path.

4.4 Staff Response to 2000 Request by the Licensee to Modify License

The Licensee requested to modify LC No. 47 in the year 2000 and, in response, NRC prepared a Technical Evaluation Report (NRC, 2000). The 2000 Technical Evaluation Report (TER) analysis can be summarized as follows.

LC 47 originally required the implementation of a groundwater compliance monitoring program for the BCUC site. In 2000, BCUC requested that LC 47 be amended to eliminate some wells from the groundwater monitoring program, add some new wells to the groundwater monitoring program, and reduce the frequency of both well sampling and submission of groundwater monitoring reports. As a part of the amendment submittal, BCUC requested that wells GW-8, GW-10, and GW-15 be removed from the groundwater compliance monitoring program. Wells GW-8, GW-10, and GW-15 were owned by local ranchers and have been used exclusively to supply water for livestock. Wells GW-8 and GW-10 are located cross gradient and west of the tailings impoundment and well GW-15 is located down gradient (north) but more than a mile from the impoundment. All three wells were developed in the Ore Sand formation. The Ore Sand is separated from the overlying alluvium and N-sand by 50 feet or more of low-permeability claystones and siltstones. Contaminant seepage from the tailings impoundment had only been detected in the shallower, hydraulically connected alluvium and N-sand and monitoring of the Ore Sand in the vicinity of the impoundment had confirmed the effectiveness of the claystones and siltstones as an aquitard. In this regard, continued monitoring of the alluvium and N-sand in the existing and proposed new monitoring wells would track the

expected attenuation of seepage contaminants well within the boundaries of the enlarged restricted area so as to provide ample opportunity for additional safeguards if the long-term water quality predictions were proven to be inaccurate. Thus, the staff agreed with BCUC that continued monitoring of the offsite wells GW-8, GW-10, and GW-15 was unnecessary.

In order to address State of Wyoming concerns about future groundwater quality at the BCUC site, BCUC proposed to add four new wells (MW-108, MW-109, MW-110, and MW-111) to the groundwater compliance monitoring program to monitor the groundwater along the existing Lang Draw and Northern contaminant seepage flow paths. As noted above, these wells would track the expected attenuation of the contaminants along these flow paths or otherwise provide opportunity for corrective action if groundwater models were shown to be inaccurate. BCUC proposed to sample these wells on an annual frequency for nickel, combined radium-226 and -228, thorium-230, uranium, chloride, and sulfate. As these new wells would provide added safeguards for protection of public health and safety and the environment, the BCUC proposal to add wells MW-108, MW-109, MW-110, and MW-111 to the groundwater compliance monitoring program was found to be acceptable by NRC.

LC 47A required semi-annual sampling of wells MW-9, MW-12, MW-14, MW-43, and MW-74 for nickel, combined radium-226 and -228, selenium, thorium-230, and uranium and BCUC requested that this frequency be decreased to annual sampling for the identified constituents. Annual sampling of these wells would be the same as the proposed sampling frequency for the four new wells (MW-108, MW-109, MW-110, and MW-111). Consistent with annualized sampling of these wells, BCUC also requested that the frequency in LC 47 for required submittal of the groundwater monitoring report be reduced from a semi-annual to an annual requirement. The NRC staff reviewed the groundwater monitoring data from 1996 through to 2000 for the POC wells MW-12 and MW-74 and noted that all of the constituents of interest (beryllium, cadmium, chromium, molybdenum, selenium, thorium-230, nickel, combined radium-226 and -228, and uranium) were in compliance with the groundwater protection standards established in LC 47B and consistent with parameter values observed in the background well, MW-9. Given the stability of these monitored parameters, the relatively slow movement of groundwater in the alluvium and N-sand, the lack of any identified use for the alluvium and N-sand water, and the added protection provided by an enlarged restricted area, the staff concluded that protection of public health and safety and the environment would not be diminished by annual sampling of the wells specified in LC 47A rather than semi-annual sampling. Accordingly, BCUC's request for annual sampling of these wells was found to be acceptable by NRC. Correspondingly, BCUC's request for annual submittal of the groundwater monitoring report was also found to be acceptable by NRC.

While considering BCUC's request to amend specific elements of LC 47, the staff evaluated the other elements of LC 47 to determine their utility or merit, given the status of the BCUC facility as a reclaimed site proceeding towards License termination. Based on this review, the staff determined that additional modifications to LC 47 were warranted. Specifically, the staff believed that the monitoring requirements in LC 47A for the specified contaminant indicator parameters in wells MW-9, MW-12, MW-14, MW-43, and MW-74 were no longer necessary. The staff also believed that monitoring requirements for MW-2 for the specified contaminant indicator and radiological parameters were unnecessary. The primary purpose of the monitoring in these wells had been to provide early indication of seepage or leakage of contaminants from the tailings impoundment when potential significant sources of leakage were available from the existence of tailings ponds and slimes. However, the ponds had since been

removed and the tailings largely consolidated (dewatered). As such, the leakage sources no longer existed and the required monitoring no longer served its original purpose. The staff concluded that this monitoring was no longer necessary, especially in light of the groundwater protection standards in LC 47B for the POC wells MW-12 and MW-74 and the added safeguards provided by the new wells (MW-108, MW-109, MW-110, and MW-111) and the enlarged restricted area. Accordingly, the staff recommended that the monitoring requirements in LC 47A for the specified contaminant indicator parameters in wells MW-9, MW-12, MW-14, MW-43, MW-74, and MW-2 (all parameters) be deleted. This recommendation was discussed with, and was agreeable to, the Licensee.

The staff also believed that, for the following reasons, the compliance requirements in LC 47B for concentrations of nickel, combined radium-226 and -228, and uranium at the specified POE locations for the Lang Draw and Northern flow paths were essentially duplicative of the corresponding compliance requirements in LC 47B for concentrations of those same constituents at the POC locations (wells MW-12 and MW-74). There was no independent measurement of the constituents of interest at the POE locations and compliance (or noncompliance) at the POE locations was inferred from the measured concentrations of these constituents at the POC locations. Thus, if BCUC was in compliance with the groundwater protection standards at the POC locations, it was presumed that it was also in compliance with the groundwater protection standards at the POE locations, consistent with the flow and geochemical modeling performed by BCUC that was the basis for the groundwater protection standards established for the POE locations. If BCUC was not in compliance with the standards at the POC locations, LC 47C required a corrective action program by BCUC to return the concentrations of the affected constituents to the established limits in LC 47B. Presumed noncompliance with the standards at the POE locations also required corrective action by BCUC, but this action was essentially duplicative of the action already required by any noncompliance determined at the POC locations. As such, the groundwater protection standards established for the POE locations were determined to serve no useful purpose and the staff recommended their deletion from the License. This recommendation was discussed with, and was agreeable to, the Licensee. Subsequently the License was amended and the reference to POE wells was deleted.

The above staff analysis from the 2000 TER continues to be relevant to current conditions at the site and is useful in determining the sufficiency of the revised ground water model. Also, despite the deletion of the references to the POE wells, the 1997 POE wells, as well as the proposed new POE wells, were still sampled annually along with the POC wells as required by WDEQ. The results of these samplings are provided below. Values for 2011 are from the February 2011 sampling event

4.5 Tables of Monitoring Results for Selected Wells from 2002 to 2011

MW-12 (POC for Lang Draw)*

	Ni (mg/L)	U-nat (pCi/L)	Ra-226 (pCi/L)	Ra-228 (pCi/L)	Th-230 (pCi/L)	SO_4 (mg/L)	pH	Conductivity
2002	0.011	731	1.4	ND	0.4	NR	6.4	NR
2003	0.016	667	1.7	ND	ND	NR	6.4	5800
2004	0.018	630	1.3	ND	ND	NR	6.6	6120
2005	0.025	571	1.4	1	0.2	NR	6.6	6115
2006	0.05	510	1.3	1	0.2	NR	6.6	6270
2007	0.05	536	0.9	1	0.2	NR	6.1	6200
2008	0.04	532	0.61	3.1	0.2	NR	6.2	6180
2009	0.039	501	1.9	2.9	0.65	2800	6.1	6190
2010	0.040	438	0.73	3.1	0.02	NR	6.3	6270
2011	0.035	420	0.62	2.4	-0.03	NR	NR	NR
2012	0.042	408	0.93	2.3	0.06	NR	NR	NR

*No Chloride value for this well
NR = not reported
ND = non detect

MW-14 (1997 POE for Lang Draw)

	Ni (mg/L)	U-nat (pCi/L)	Ra-226 (pCi/L)	Ra-228 (pCi/L)	Th-230 (pCi/L)	Cl (mg/L)	SO_4 (mg/L)	pH	Conductivity
2002	0.02	252.5	0.6	ND	ND	NR	NR	NR	NR
2003	0.02	264.7	2.3	ND	ND	NR	NR	6.8	5290
2004	ND	262.7	1.1	ND	ND	NR	NR	6.8	5150
2005	0.03	367.6	1.1	2.1	<0.2	NR	NR	6.7	5450
2006	0.03	376.4	0.7	1.9	<0.2	NR	NR	6.6	5470
2007	0.05	459.0	0.2	1	0.2	NR	NR	6.2	5450
2008	0.06	520.6	0.35	1.4	0.2	NR	NR	6.3	5500
2009	0.01	454.9	1.2	1	0.62	300	2000	6.3	5260
2010	0.06	438.7	0.06	0.6	0.08	NR	NR	6.3	5420
2011	0.04	439	0.09	0.08	0.1	NR	NR	NR	NR
2012	0.14	452	0.57	2.2	0.06	NR	NR	NR	NR

MW-109 (New POE for Lang Draw)

	Ni (mg/L)	U-nat (pCi/L)	Ra-226 (pCi/L)	Ra-228 (pCi/L)	Th-230 (pCi/L)	Cl (mg/L)	SO_4 (mg/L)	pH	Conductivity
2002	0.009	39	0.8	ND	ND	12.5	1800	7.1	3140
2003	0.009	32	0.9	ND	0.2	11.8	1770	7.0	3150
2004	ND	27	1.2	ND	ND	16	1860	7.1	3170
2005	0.017	32	1	ND	<0.2	20	1740	7.2	3130
2006	0.009	33	0.6	1	<0.2	25	1790	7.2	3250
2007	0.05	41	0.8	1	0.2	33	1920	6.6	3210
2008	0.05	41	0.72	3.4	0.2	31	1890	6.8	3080
2009	<0.01	60	0.82	1.3	0.07	52	1770	6.9	3050
2010	0.01	64	0.7	1.4	0.04	79	1890	7.0	3190
2011	0.013	61	0.5	1.3	-0.05	89	1900	7.0	2353
2012	0.006	52	0.58	0.7	0.004	103	1910	NR	NR

MW-74 (POC for Northern Flow Path)

	Ni (mg/L)	U-nat (pCi/L)	Ra-226 (pCi/L)	Ra-228 (pCi/L)	Th-230 (pCi/L)	Cl (mg/L)	SO_4 (mg/L)	pH	Conductivity
2002	0.01	103	2.8	4.6	4.1	250	3210	NR	NR
2003	0.01	60	2.3	ND	ND	250	2960	6.2	3860
2004	ND	53	1.8	ND	ND	260	3300	6.7	3970
2005	0.01	109	2.7	2.8	<0.2	235	3110	6.5	4190
2006	0.02	51	1.8	2.0	<0.2	220	3310	6.5	4170
2007	0.05	20	1.8	1.9	0.2	235	3380	5.8	4000
2008	0.05	16	2.2	5.3	0.2	235	3380	5.9	4020
2009	0.03	16	3.6	3.5	0.02	240	1800	5.8	3820
2010	0.17	16	2.4	3.4	0.05	NR	NR	5.8	3870
2011	0.04	15.4	1.8	4.0	-0.09	NR	NR	NR	NR
2012	0.07	14.6	2.6	4.0	0.05	NR	NR	NR	NR

MW-43 (1997 POE for Northern Flow Path)*

	Ni (mg/L)	U-nat (pCi/L)	Ra-226 (pCi/L)	Ra-228 (pCi/L)	Th-230 (pCi/L)	Cl (mg/L)	SO_4 (mg/L)	pH	Conductivity
2002	0.005	33.9	5.2	5.6	ND			NR	NR
2003	0.003	45.4	3.7	ND	0.2			6.5	4500
2004	ND	54.8	3.2	ND	0.2			6.7	4546
2005	0.001	42.9	3.8	2.8	<0.2			6.8	4440
2006	0.006	66.5	2.1	2	<0.2			6.7	4240
2007	0.05	20.3	3.2	1.9	0.04			6.5	3940
2008	0.05	26.0	2.2	5.3	ND			6.5	3880
2009	<0.01	29.1	3.2	3.5	ND			6.3	3830
2010	0.02	37.0	2.3	4.7	0.08			6.4	3820
2011	0.017	38.0	1.8	3.1	-0.07			NR	NR
2012	0.02	38.6	1.9	4.3	0.001			NR	NR

*No chloride or sulfate data for this well

MW-111 (New POE for Northern Flow Path)

	Ni (mg/L)	U-nat (pCi/L)	Ra-226 (pCi/L)	Ra-228 (pCi/L)	Th-230 (pCi/L)	Cl (mg/L)	SO_4 (mg/L)	pH	Conductivity
2002	ND	18	1.1	ND	ND	60.1	525	7.0	1777
2003	0.002	11	1.7	ND	ND	75	730	7.4	1785
2004	ND	16	1	ND	ND	90	919	7.3	2150
2005	0.002	16	1.8	1.4	<0.2	886*	803	7.4	2170
2006	<0.005	15	1	1.6	0.2	98	978	7.4	2310
2007	0.05	16	0.2	1	0.2	109	2160	6.9	2390
2008	0.05	16	0.61	3.8	0.2	109	1100	7.0	2450
2009	0.01	16	1.1	1.9	0.02	101	1110	6.9	2500
2010	0.03	17	0.01	2.3	0.01	101	1200	6.9	2540
2011	0.004	17.6	0.042	1.4	-0.06	102	1190	6.8	2430
2012	0.006	16.7	0.53	0.6	0.03	116	1340	NR	NR

*Appears to be a reporting error

5.0 FLOW AND TRANSPORT MODELING

5.1 1997 ACL Modeling Summary (From APC, 2011)

As part of BCUC's 1997 ACL License amendment application, GeoTrans, Inc. (now called Tetra Tech GEO) performed a geochemical evaluation and predictive modeling of the future groundwater transport of uranium, radium, and nickel originating from the BCUC tailings impoundment, based on chemical conditions that existed at that time (i.e., 1995). An important consideration at that time was the prediction of the neutralization capacity of the downgradient native alluvium and rock that contained calcite (an acid buffering mineral). Measurements of the acidity of the water and the neutralization capacity of the alluvium and rock were made, and calculations indicated that the movement of low pH water would be retarded due to the neutralization reactions. For Lang Draw, the 1995 study estimated that the retardation factor of the pH front would be significant; approximately 10 for the area upgradient of the tailings impoundment seepage control dam, and approximately 15 for the area downgradient of it. The study also found that the concentrations of metals arsenic, beryllium, cadmium, chlorine, thorium, and radium all decreased sharply as the pH increased above approximately 4.5, as did the concentrations of iron and aluminum. This behavior was interpreted as being indicative of coprecipitation of the former list of metals with iron and aluminum hydroxides. During the 1995 modeling effort, GeoTrans used MINTEQA2, an equilibrium speciation model that can be used to calculate the equilibrium composition of dilute aqueous solutions in natural aqueous systems, to perform the geochemical speciation modeling to estimate retardation coefficients of uranium and nickel, and other laboratory measurements for radium and thorium. The results of this study indicated that the metals would move more quickly than the pH front, and therefore one-dimensional transport models using linear sorption theory were prepared to predict future movement.

GeoTrans used the MINTEQA2-generated retardation coefficients as input to BIO1D, a one-dimensional ground water flow and transport code that uses linear sorption to simulate retardation. Because the pH front was estimated to move more slowly than other constituents in the water, the model was simulating contaminant transport downstream of the lower pH area.

Initial concentrations were based on water samples collected as part of that study. The model assumed that water would begin moving downgradient of the BCUC site once the groundwater recovery system was turned off (i.e., capture of the contaminants of concern beneath and a short distance downgradient of the tailings impoundment would end, and impacted water would begin moving downgradient again).

GeoTrans' predictions of peak uranium concentrations at the BCUC site property line (near MW-14) were between approximately 50 and 70 pCi/L, depending on the amount of dilution from convergent flow into Lang Draw, with the peak occurring approximately 80 years after 1995, or in 2075. Nickel was estimated to travel more slowly, with the peak concentration ranging between approximately 0.05 and 0.85 mg/L in about 2250. These modeling predictions were used in the 1997 ACL application. The ACLs for uranium, radium, and nickel were set at 2,038 pCi/L, 46 pCi/L, and 3.8 mg/L, respectively, with the points of compliance established at MW- 12 for Lang Draw and MW-74 for the northern flow path. These ACLs were based on the model results indicating that concentrations at the point of exposure wells for uranium, radium, and nickel would be 45 pCi/L, 13 pCi/L, and 0.55 mg/L, respectively. As discussed in Section 4.2, NRC staff granted the 1997 ACL License amendment application and amended the License to reflect the revised ACLs in June 1997.

5.2 2010 Review of 1997 Model Predictive Accuracy

The 1997 ACL application contained predictive ground water contaminant transport modeling results that indicated that the maximum concentration of nickel, radium, and uranium, at the POC locations (wells MW-12 and MW-74—see Site Map) would be 3.8 mg/L, 46 pCi/L, and 2,038 pCi/L, respectively. Similarly, maximum concentrations of nickel, radium, and uranium at the 1997 POE locations (wells MW-14 and MW-43) would be 0.55 mg/L, 13 pCi/L, and 45 pCi/L, respectively. In preparation for the transfer of the BCUC site to DOE for Long-Term Care, the NRC staff tabulated the ground water data from the date of the 1997 ACL application until 2010. Evaluation of the data indicated that the uranium concentration in well MW-14 (1997 Lang Draw POE well) exceeded the predicted concentration of 45 pCi/L on several occasions and reached 520 pCi/L in 2008, more than 10 times the predicted value. These analytical results called into question the predictive accuracy of the GeoTrans geochemical evaluation of future contaminant transport. As a result, the NRC staff requested that a new risk-based ACL application be submitted incorporating the ground water data collected over the 14 years since the original ACL application.

5.3 2011 ACL Modeling Summary (From APC, 2011)

In response to NRC's request for a revised ACL application based on the additional years of ground water data, a new predictive ground water flow and transport model was submitted by the Licensee. The new ACL model has two significant advantages over the 1995 model: 1) data are available regarding the transport of uranium and other constituents along Lang Draw and the Northern Flow Path for use in calibration of the model and 2) modeling technology has improved allowing direct incorporation of the chemical reactions into the transport model. Separate models were constructed for Lang Draw and for the Northern Flow Path.

The 2011 modeling effort utilized PHREEQC, a computer program for simulating chemical reactions and transport processes in natural or polluted water. As opposed to the previous 1995 effort, PHREEQC uses higher, undiluted source area concentrations and incorporates

coefficients for uranium sorption onto ferrihydrite. The current model also assumes equilibrium with gypsum and supersaturation with respect to ferrihydrite. These assumptions are in keeping with the findings of the speciation model. The initial water concentrations at various points in the model are adjusted to match observed concentrations during the earlier part of the simulation period, and concentrations upgradient of the pH front were adjusted to match observed breakthrough concentrations in downgradient monitoring wells. Further, the influx of water from tailings was decreased through time to reflect the decline in the rate of seepage from the tailings following construction of the cover. Chemistries of downgradient water used in the model were based on samples that had been collected from monitoring wells at about the time that the recovery system was turned off.

The two models (Lang Draw and the Northern Flow Path) were constructed to begin beneath the tailings impoundment and extend downgradient to the northern property boundary, along each flow path. Model lengths of 968 meters (3,175 ft) and 1,040 meters (3,412 ft) were used for Lang Draw and the Northern Flow Path, respectively. The grid spacing was 4 meters, resulting in models with 242 cells and 260 cells, respectively. Time steps of approximately 1 month were used in each model. As would be expected with a reactive transport model with sharp changes in chemical parameters, especially pH, some minor numerical issues occurred early in the simulations. These quickly smoothed out both laterally and temporally as the sharp fronts were smoothed by the dispersive process that the model can simulate.

Concentration data for uranium, sulfate, chloride, radium, and nickel observed in monitoring wells MW-12, -14, -108, and -109 were used as calibration targets for the Lang Draw flow path, and in wells MW-74, -43, -110, and -111 for the Northern Flow Path. During calibration of the models, the primary emphasis was on developing acceptable matches to the timing and magnitude of the breakthrough of uranium at the different monitoring wells, followed by simulating the sulfate and chloride concentrations. Other observations (radium for example) did not show a breakthrough pattern that could be used to assist the calibration of the model. A fact that became apparent early in the calibration process was that there was considerable spatial variability in the breakthrough behavior at different wells. MW-9 is a well that is completed at greater depth than MW- 14, and even though MW-9 is closer to the tailings impoundment than MW-14 is, breakthrough occurs more slowly in MW-9. The breakthrough curves for chloride for MW- 14 and MW- 108 are nearly identical, even though they are nearly 700 feet apart. Because the peak uranium concentrations have already been observed in MW-12 and -14 along Lang Draw, the more recent data provide significant information on the rate of movement and the peak concentrations needed for predicting future movement.

5.4 2011 ACL Modeling Results (From APC, 2011)

5.4.1 Lang Draw

Uranium - Uranium is retarded in its movement by sorption to ferrihydrite, and its transport is therefore affected by the amount of ferrihydrite present in the aquifer solids, as well as by the rate of water movement and by dispersion. The amount of ferrihydrite is primarily determined by the amount of dissolved iron in the low pH water at the upgradient end of the pathway, and by the change in pH downstream of the pH front, which causes the dissolved iron to precipitate as ferrihydrite. At MW-12, the most upgradient monitoring well, uranium concentrations peaked at 731 pCi/L in July 2003. At MW-9, which is the next monitoring well down the flow path, concentrations are lower and it is not clear at this time whether they have peaked. MW-9 is

monitoring bedrock beneath the alluvial channel, and thus the uranium breakthrough is different in this well than in the more rapid alluvial channel part of the flow system. Uranium concentrations in MW- 14 have also peaked (July 2008) and are declining. This well is completed in the alluvial materials, and the breakthrough is similar to that observed in MW- 12, but delayed. At MW-108 and -109, it is not clear whether the peak has arrived yet. The calibrated model matches the observed uranium concentrations in MW-12 and -14 reasonably well. At MW-12, the simulated breakthrough occurs earlier than observed, and the concentrations drop off more quickly than observed. The tailing (slower decline than rise) in the data is probably caused by the heterogeneity in the sediments. Concentrations in the future will probably decrease more slowly than the model will predict. The model predicts peak concentrations should have already reached MW-9, where the data indicate that transport is occurring much more slowly. Because the model is addressing transport in the more permeable alluvial sediments, it predicts more rapid transport to this location than was observed. Similarly, the model has predicted much more rapid transport to MW-108 and -109, than has been observed. These wells are also completed in the bedrock, and thus would be expected to peak more slowly than predicted.

The uranium results show a double peak. The second peak is approximately one-third to one-half of the height of the first peak. The second peak is caused by the movement of the pH front. Even though the reduction in pH is small, it causes dissolution of ferrihydrite and releases some of the sorbed uranium which migrates downgradient creating the second peak. Because the model assumes homogeneity within different parts of the model, whereas the natural system is heterogeneous, the natural system may not show a clearly discernable second peak. It may create a long tailing effect, similar to what is shown for the most downgradient well, MW-109. The model predicts that uranium concentrations will be approaching background concentrations in approximately 2050; there is uncertainty in this estimate primarily because of heterogeneity, but also because there are many parameters, such as groundwater velocity, dispersion, and thermodynamic data that are uncertain. The availability of the uranium concentration data through and past the time when the first peak occurred provides a constraint on the calibration of the model, especially with respect to the peak concentration. While the timing of the return to background concentrations is not well-defined because the peak has just passed MW-12 and -14, it is unlikely that uranium concentrations will exceed the peak concentrations previously observed.

Sulfate - The movement of sulfate is determined by the water velocity and whether gypsum will dissolve or precipitate. As gypsum is composed of calcium and sulfate, the concentration of sulfate is inversely proportional to the concentration of calcium if gypsum is present. The geochemical speciation modeling discussed above indicated that gypsum is present throughout the area. The model simulates a peak for sulfate at MW- 12 approximately 8 years after the pumping stopped. There is a gap in the measurements at about that time, but concentrations measured later are higher than the simulated values, suggesting that either breakthrough occurred more slowly than simulated, or that heterogeneity is causing tailing. The timing of the simulated peaks are coincident with those of uranium. At MW- 12, the model matches the sulfate concentrations reasonably well, but over predicts them at other locations. This may indicate that the concentrations of calcium used in the model are too low.

Sulfate concentrations are predicted to have a single peak, as sulfate does not sorb to ferrihydrite. The model simulates that the sulfate peak will pass through the wells, and the concentration in each will then decline to a value of approximately 1,600 mg/L.

Chloride - Chloride behaves conservatively. In other words, it is not retarded by a chemical mechanism such as sorption or precipitation. The peaks of the simulated breakthrough occur earlier than the peaks for uranium and sulfate. Although the data is quite variable, the model matches the breakthrough of chloride reasonably well except at MW-109. The difference in the measured breakthrough curves for MW-108 and -109 is surprising. Breakthrough of uranium and sulfate has not occurred at these two wells, so it is surprising that chloride did breakthrough as early as it did. Peak chloride concentrations are matched well.

The breakthrough of chloride is also single-peaked. Concentrations decrease downgradient because of dispersion processes. The model predicts that concentrations at the monitoring wells will decline to the upstream input concentration within about 25 to 40 years after the pumping stopped, or in about 2025 to 2040. However, heterogeneity causes slower recovery than predicted by homogeneous models, and recovery may take longer than predicted.

*pH***-** The pH values varied over the range of approximately 6.1 to 7.5 in the data. The data indicate that pH has decreased in MW-12, -9, -14, -108, and perhaps -109. The lowest measured pH during the post-recovery system period was 6.1. The model simulates the pH over the same approximate range as the measurements with an initial decline followed by rising pH in the three most upgradient wells.

The model showed the pH front (from higher to lower pH) during the calibration period, with MW- 12 and MW-9 showing increasing pH toward the end of it. In the longer run of the model, the pH increases at all locations to a value of approximately 7. The model predicts that about 4 decades will be required for the pH to become stable, but the range in pH over this period is small.

Radium - Concentrations of radium have been variable over this time frame, and may have peaked in approximately 2003. In MW-14, concentrations have generally been declining since the beginning of the period. Concentrations in MW-14 and MW-12 appear to have been higher than in MW-9, -108, and -109. Because radium concentration is determined by counting, and because the concentrations are low, the observed variability is likely due in large part by random counting error. There did not appear to be a reliable signal against which to calibrate the model. As a result, the timing of the peaks is essentially unconstrained, and determined by the groundwater velocity. In the resulting predictions, the range of concentrations is believed to be representative, but the timing of the breakthrough is not.

As discussed above, radium was assumed not to sorb because of the difficulty in interpreting the measurements. As a result, it is predicted to peak relatively quickly, with maximum concentrations between 2.0 and 2.5 pCi/L. This concentration is based on the observed concentrations over the previous 15 years. Radium concentrations had been as high as 18 pCi/L in the early 1990s, but have not risen much since pumping stopped. The simulations predict that the peak has already passed for many of the monitoring wells, but retardation of radium was not simulated because it does not sorb appreciably to ferrihydrite.

Nickel - Nickel appears to be increasing in concentration in MW- 12 and -14, but concentrations have typically been higher in MW-14, the downgradient well. Some of the results at MW-109 have been nearly as high as those in upgradient wells. Thus, the high variability in the data made it difficult to select calibration targets. Nickel concentrations are lower than prior to the

recovery system pumping, but may be trending upward. In the simulation, nickel is retarded by sorption onto ferrihydrite. The model predicts that the nickel peak will pass through MW-109 a little slower than that of chloride, with the concentrations not increasing appreciably above those seen today.

5.4.2 Northern Flow Path

The transport of the parameters along the Northern Flow Path is similar to that along Lang Draw except that the concentrations are lower and the rate of movement is slower. This is a consequence of the slower velocity (65 ft per year) and longer flow path as compared to Lang Draw.

However, the maximum predicted concentration of nickel (0.34 mg/L in 2039) and combined radium (5.8 pCi/L in 2040) are higher than for the Lang Draw values for nickel (0.032 mg/L in 2015) and combined radium (2.1 pCi/L in 2015).

5.5 2012 ACL Modeling Results (From Tetra Tech Geo, 2012)

The 2011 modeling results, presented in Section 5.4, matched sampling data in monitoring wells close to the tailings impoundment, but the simulated concentrations at two downgradient wells (MW-108 and MW-109) were significantly higher than observed. NRC staff asked the Licensee to calibrate their model to better match observed concentrations in these two wells. A revised model was submitted in September 2012 (Tetra Tech Geo, 2012).

In the 2011 model, the concentration of ferrihydrate, a naturally occurring iron compound that will assist the sorption of uranium to sediments and hinder uranium transport in ground water, was simplified so its concentration was uniform throughout the model, and set to a very low concentration of 0.00001 moles per liter of water. In the current 2012 model, the concentration of ferrihydrate ranged from 0.004 moles per liter to 0.9 moles per liter, based on reported measurements of total iron present in the Wasatch Formation and the distance from the tailings impoundment.

The simulated and observed concentrations of uranium from the 2012 model are shown in Figure 4. At the proposed POE well, MW-109, the model matches the observed concentrations well. Figure 5 shows the predicted concentrations of uranium to the year 2084. The modeled transport of uranium through MW-109 is delayed due to the high concentration of ferrihydrate in the model. Since a decrease in pH has already occurred without causing an increase in uranium concentration, plus the difference in the trends of uranium concentrations in the observations and simulations, indicate that the model is predicting higher future concentrations in MW-109 than will occur.

6.0 HAZARD AND EXPOSURE ASSESSMENTS

6.1 Results Using 2011 Model

The 2011 ACL model results reaffirmed the finding of the 1997 ACL model that, at the POC, the concentration of hazardous constituents will not exceed the 1997 ACLs, that the 1997 ACLs are as low as reasonably achievable, and that the constituents will not pose a substantial present or potential hazard to human health or the environment, as long as the ACLs are not exceeded.

However, the 2011 modeling also found that the concentrations of nickel, radium, and uranium within the long term surveillance boundary, though not in excess of the 1997 ACLs at the POC, are greater than previously estimated. The NRC has determined that the human health hazard associated with this increase is minimal based upon the following discussion.

The carcinogenic and non-carcinogenic risks associated with exposure to radium, uranium, and nickel under a residential future land use scenario were used for the human health hazard assessment. The human health hazard assessment was made under the provisions of 10 CFR Part 40, Appendix A, criterion 5B(6), and using the Exposure Assessment guidance in NUREG-1620, Rev. 1. Although there is no current indication that the ground water in the Northern flow path and the Lang Draw flow path will be utilized under a residential scenario, this type of use was conservatively assumed to take place. A lifetime exposure of 75 years was used for the calculations. The exposure pathways under the residential land use scenario included the ingestion of contaminated ground water and the ingestion of home grown produce irrigated with contaminated ground water.

The maximum predicted concentrations for nickel and combined radium used in the hazard assessment were the values given in Section 3.2.4.2 of the ACL application (APC, 2011). The value for uranium was the average of the model projected curve (166 pCi/L for the Lang Draw and 75 pCi/L for the Northern Flow Path) which is used as the chronic exposure for 75 years.

The ingestion over 75 years of these predicted concentrations of uranium and radium in the ground water will cause a minimal increase in the acceptable risk of cancer to potential future residents. Risks of developing cancer from ingesting ground water and eating produce irrigated with water containing these radionuclides are 2.2×10^{-4} and 4.2×10^{-4} in the Northern flow path and the Lang Draw flow path, respectively. The Licensee also did a risk calculation using the background values for uranium (98.7 pCi/L) and total radium (9.7 pCi/L) and the resultant calculated risk of developing cancer was 4.3×10^{-4}.

Nickel was remanded from the EPA Primary Drinking Water Standards in 1995 but the Licensee used the previous maximum concentration level (MCL) to show relative risk for ingested nickel. The projected concentrations of nickel at the proposed POE wells are less than the previous EPA MCL for nickel showing that the human health hazard from nickel are within recommended levels.

6.2 Results Using 2012 Model

The predicted uranium concentration over the next 75 years presented in Figure 5 shows a peak of about 275 pCi/L in the year 2060. The average concentration over the 75 year period is about the same as the 2011 model, just delayed. Therefore, the risk calculation for uranium will be similar under both the 2011 and 2012 results.

6.3 Assessment of Results

These risks calculated under a residential scenario are slightly higher than the acceptable ACL guidance levels found in Section 4.3.3.2 of NUREG-1620, Rev. 1, which states, “A proposed alternate concentration limit that does not exceed an excess lifetime risk of fatal cancer on the order of 1×10^{-4} is acceptable for an average exposed individual at the point of exposure.” However, there are several factors that need to be considered when viewing the risk

calculations and assessing total risk. First, the most important factor that will make the total risk less than the calculated risk is that there is no viable aquifer at or near the site thus the residential ingestion of ground water over a 75 year period is not a likely scenario. Second, the predicted future concentrations of uranium and total radium are likely overestimated, particularly when compared to the current sampling results. Third, the risk calculated from the background concentrations of uranium and total radium is higher than the risk calculated from the predicted future concentrations. Fourth, since the land will be under Federal control, the residential use of the land that could lead to the calculated risk is unlikely.

Therefore, the NRC finds that the total risk from the potential levels of nickel, radium, and uranium in the ground water is acceptable pursuant to 10 CFR Part 40, Appendix A, criterion 5B(6), and NUREG-1620, Rev. 1.

7.0 MONITORING AT TITLE II SITES THAT HAVE BEEN TRANSFERRED TO DOE

The following describes the current ground water monitoring regimes for the six Title II sites that have been transferred to DOE (DOE, 2011).

Bluewater, New Mexico—Ground water monitoring is required at the site. The Long-Term Sampling Plan (LTSP) requires annual sampling for polychlorinated biphenyls and triennial sampling for molybdenum, selenium, and uranium in the alluvium aquifer background and POC wells. The ACL for uranium was exceeded at an alluvium POC well. Two new alluvium monitoring wells were installed in July 2011 to further evaluate the extent of contamination.

Edgemont, South Dakota—Ground water monitoring is not required at this site, as stipulated in the LTSP, due to the presence of a 300- to 700-foot thick layer of competent unweathered shale bedrock lying between the encapsulated tailings and the uppermost confined aquifer.

L-Bar, New Mexico—Ground water monitoring is required at the site. As stipulated in the LTSP, the requirements for annual ground water monitoring were met in 2007. Consequently, the sampling frequency changed to once every 3 years beginning in fall 2010.

Maybell West, Colorado—Ground water monitoring is not required at this site because 30 years of historical monitoring performed at the site by the former Licensee indicated that ground water has not be contaminated by site-related activities.

Sherwood, Washington—Ground water monitoring is not required at this site. However, as a best management practice stipulated in the LTSP, DOE conducts limited ground water monitoring for designated indicator parameters.

Shirley Basin South, Wyoming—Ground water monitoring is required at this site. Concentrations of radium-226 and radium-228 continue to exceed ACLs.

8.0 RECOMMENDATION FOR FUTURE GROUND WATER MONITORING AT BCUC

As can be seen from the summary of the sites transferred to DOE, ground water monitoring is

required at several of the sites and not required at other sites. The Bear Creek site is similar to the Edgemont, South Dakota site. However, given the predictive uncertainty related to the revised ACL model, NRC staff believes it prudent to continue a focused ground water monitoring program along the Lang Draw. Consequently, the NRC recommends that once the License is transferred to DOE, that DOE sample the POC and POE wells along the Lang Draw for selected parameters of nickel, radium-226 and radium-228, uranium, chloride, sulfate, pH, conductivity, and water level, initially after transfer of the site, then once every 3 years for a 30-year period. The NRC staff believes that ground water quality monitoring along the Lang Draw will provide verification of the predictive accuracy of the revised ACL model over the entire recommended sampling period. Since the concentrations of the selected parameters are much lower in the Northern Flow Path, the NRC staff does not believe verification of these ACL modeling results is necessary. The predicted breakthrough values and current actual concentration values for the selected sampling parameters are presented in the Predicted Breakthroughs enclosure (Figures 4 and 5) and DOE should compare the measurements from its sampling regime to these values.

9.0 RECOMMENDED LICENSE AMENDMENT

Based on the foregoing discussion, the NRC amends the License to remove LC 47, which required annual well sampling. The NRC also recommends that the License be transferred to DOE and that DOE continue to sample the POC and POE wells along the Lang Draw as described above.

10.0 REFERENCES

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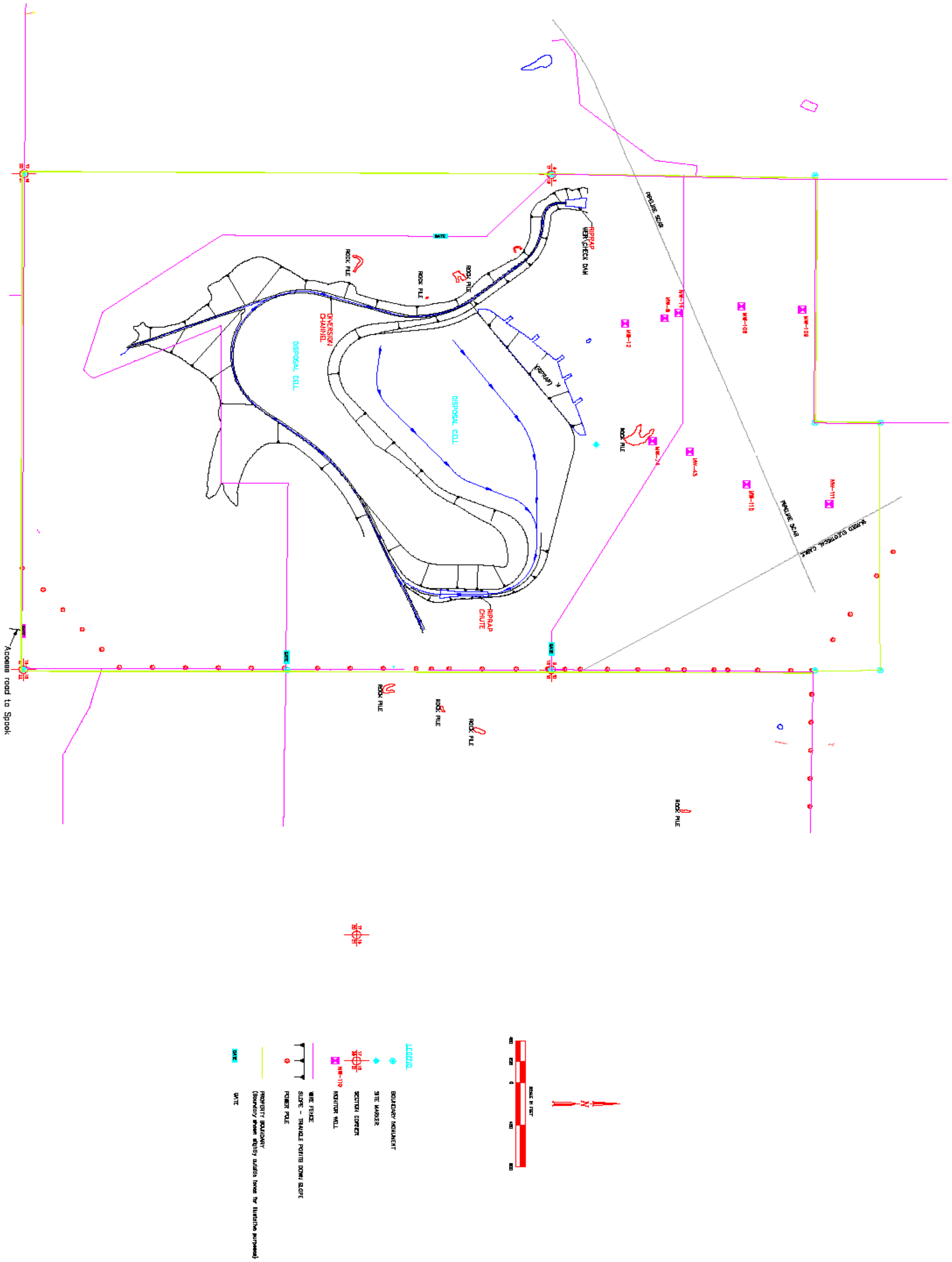

Access road to Spook
DISPOSAL CELL
DISPOSAL CELL
DIVERSION CHANNEL
RIPRAP WEIR/CHECK DAM
RIPRAP CHUTE
ROCK PILE
ROCK PILE
ROCK PILE
ROCK PILE
ROCK PILE
ROCK PILE
ROCK PILE
ROCK PILE
GATE
GATE
GATE
MW-12
MW-108
MW-111
MW-110
MW-45
MW-74
LEGEND
BOUNDARY MONUMENT
SITE MARKER
SECTION CORNER
MONITOR WELL
WIRE FENCE
SLOPE - TRIANGLE POINTS DOWN SLOPE
POWER POLE
PROPERTY BOUNDARY
GATE

FIGURES FROM 2011 MODELING

PREDICTED BREAKTHROUGH VALUES FOR POC AND POE WELLS
ALONG LANG DRAW

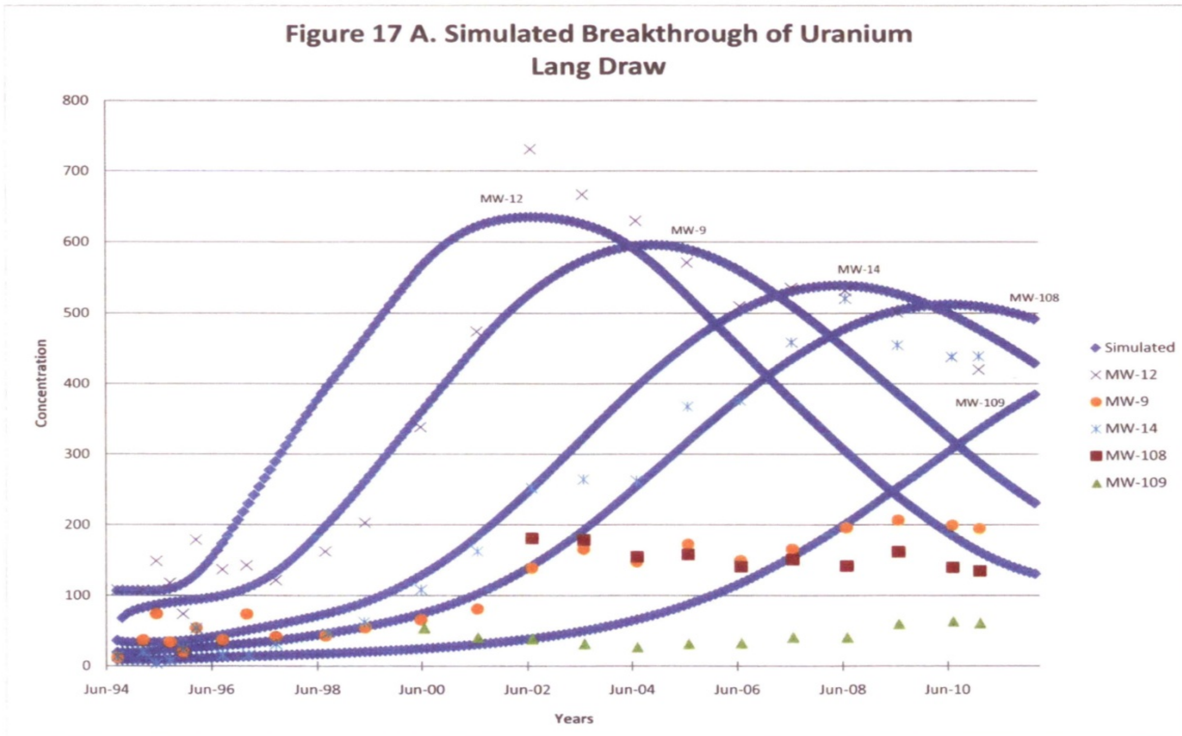
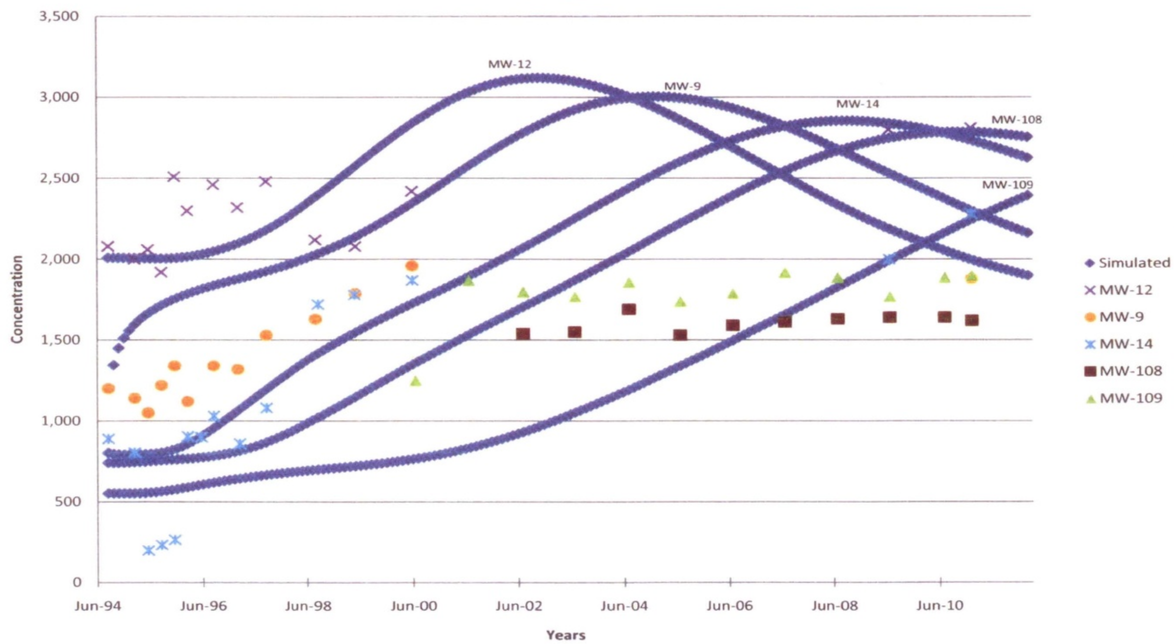


Figure 17B. Simulated Breakthrough of Sulfate Lang Draw



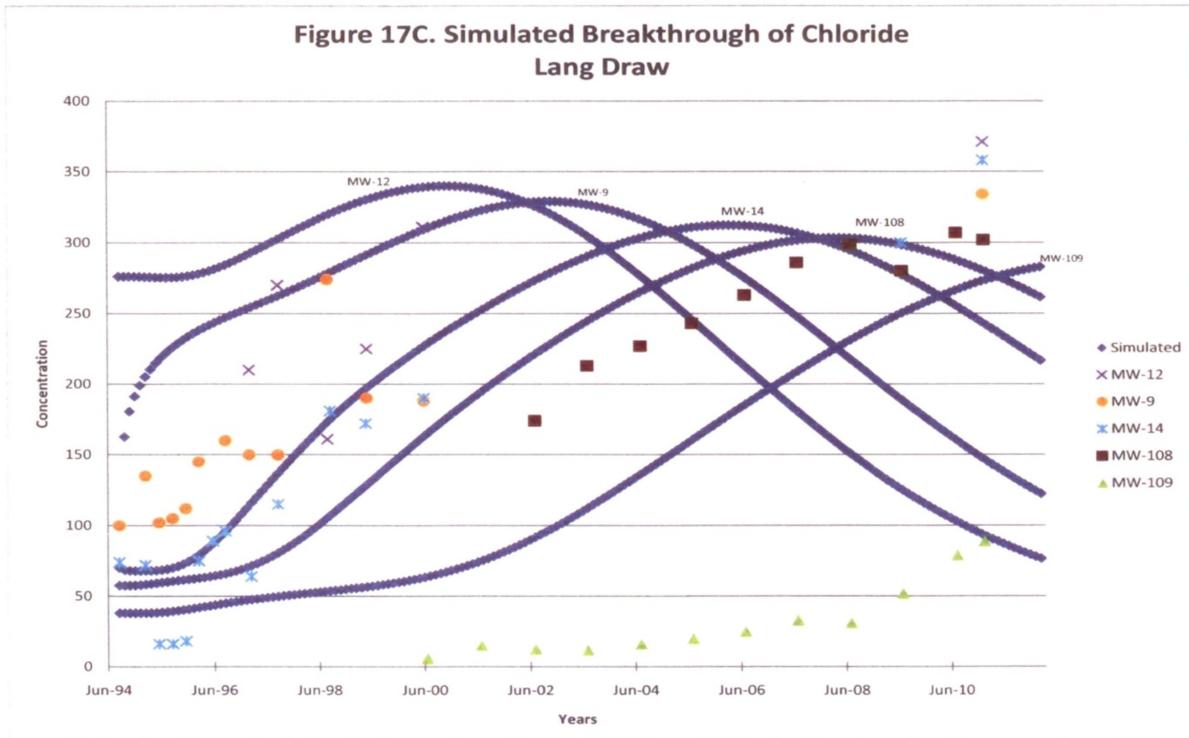


Figure 17C. Simulated Breakthrough of Chloride
Lang Draw
Concentration
400
350
300
250
200
150
100
50
0
Jun-94
Jun-96
Jun-98
Jun-00
Jun-02
Jun-04
Jun-06
Jun-08
Jun-10
Years
MW-12
MW-9
MW-14
MW-108
MW-109
Simulated
MW-12
MW-9
MW-14
MW-108
MW-109

Figure 17D. Simulated Breakthrough of pH Lang Draw

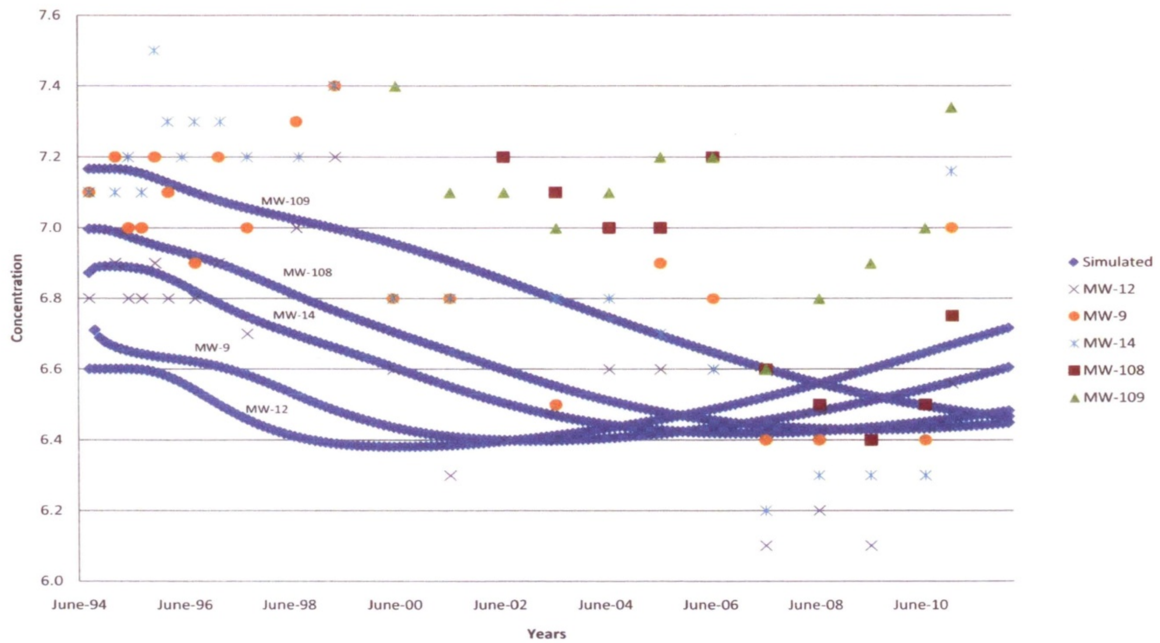


Figure 17E. Simulated Breakthrough of Radium Lang Draw

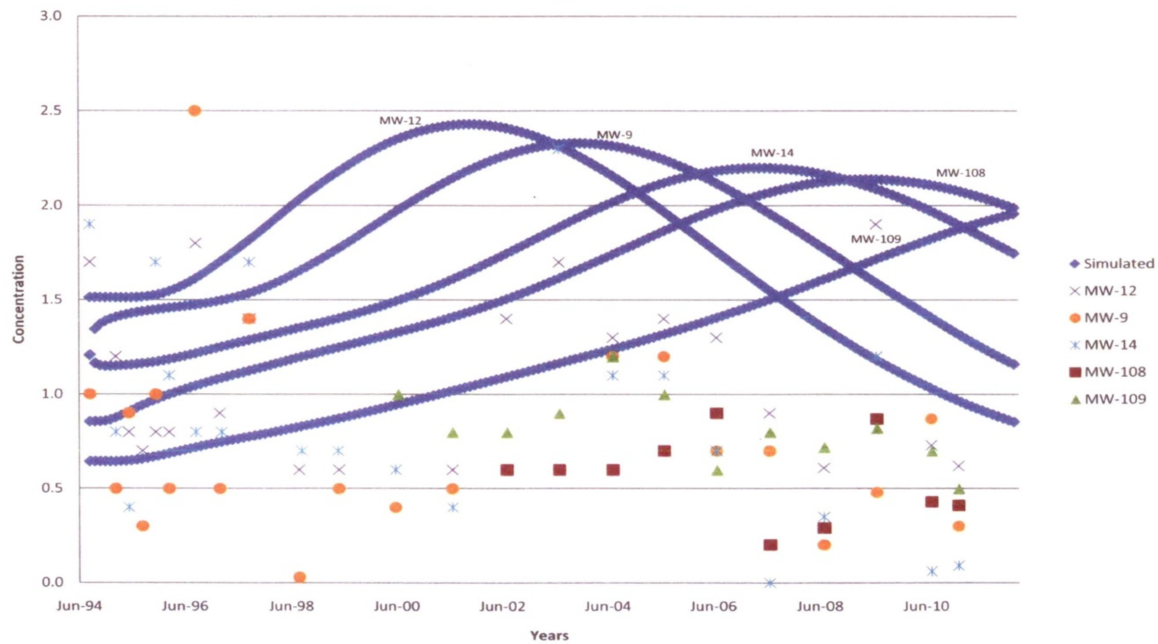
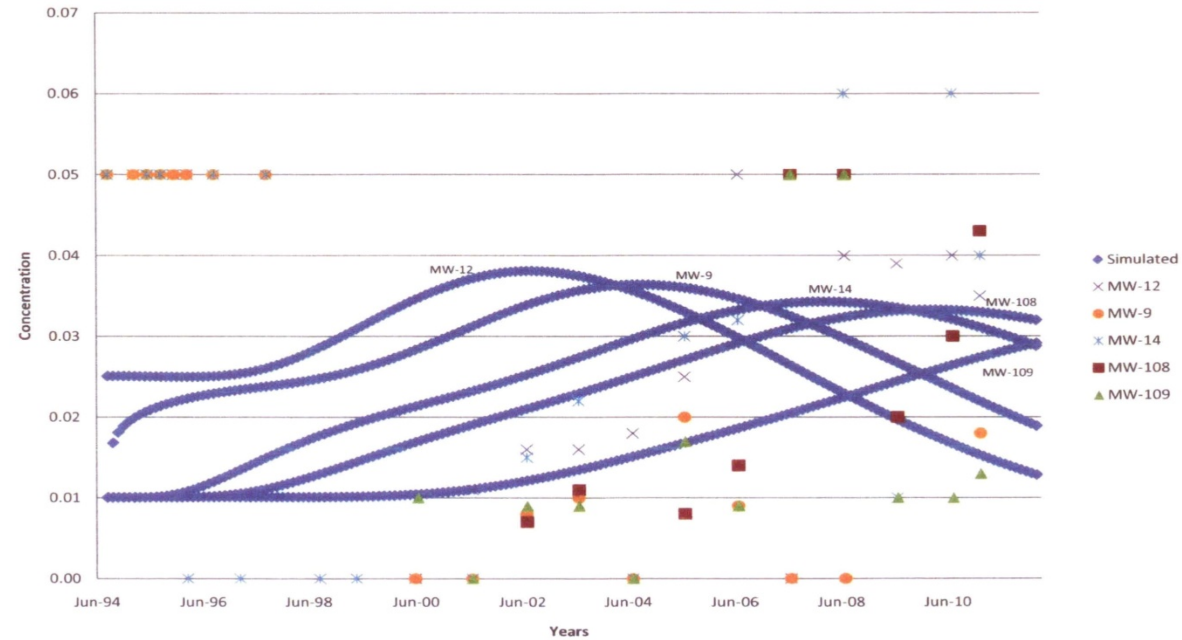


Figure 17F. Simulated Breakthrough of Nickel
Lang Draw



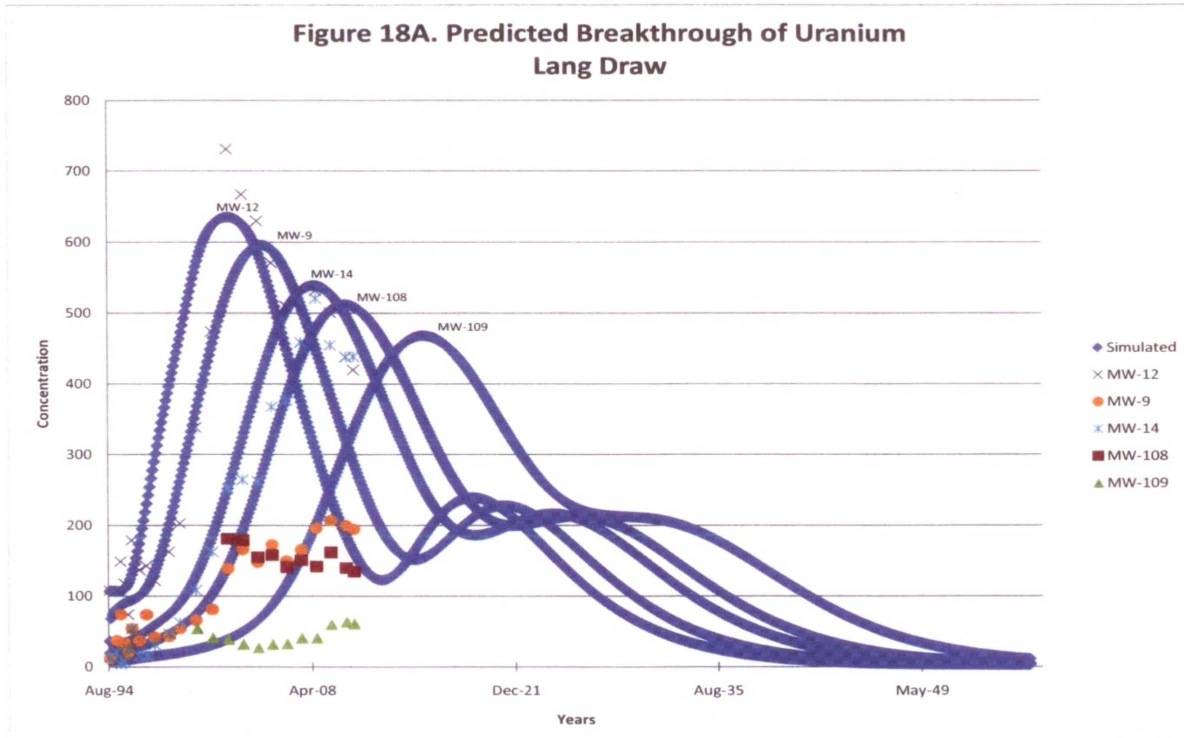


Figure 18A. Predicted Breakthrough of Uranium
Lang Draw
Concentration
800
700
600
500
400
300
200
100
0
Aug-94
Apr-08
Dec-21
Aug-35
May-49
Years
MW-12
MW-9
MW-14
MW-108
MW-109
Simulated
MW-12
MW-9
MW-14
MW-108
MW-109

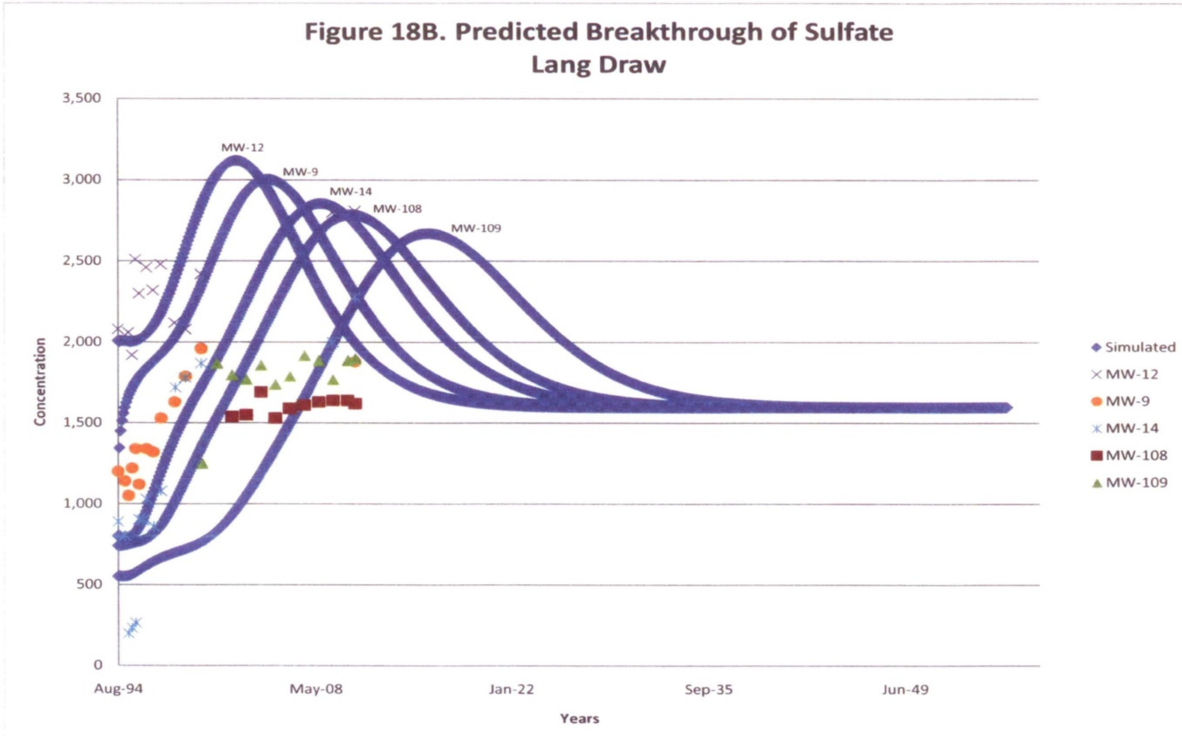


Figure 18B. Predicted Breakthrough of Sulfate
Lang Draw
Concentration
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Aug-94
May-08
Jan-22
Sep-35
Jun-49
Years
MW-12
MW-9
MW-14
MW-108
MW-109
Simulated
MW-12
MW-9
MW-14
MW-108
MW-109

Figure 18C. Predicted Breakthrough of Chloride Lang Draw

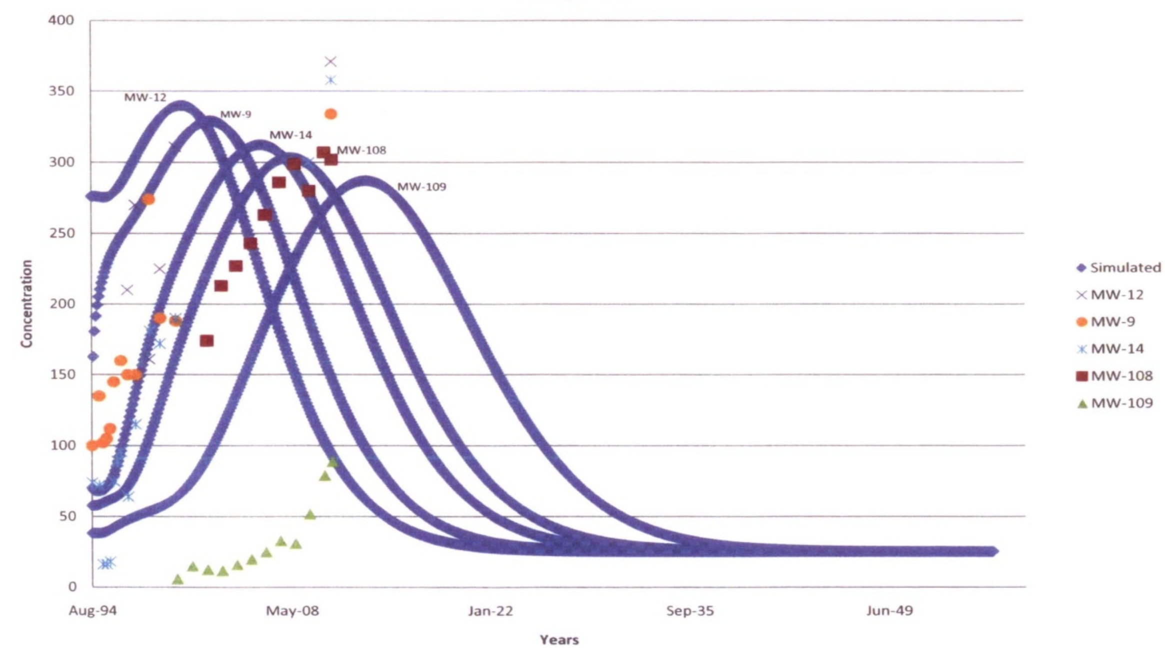


Figure 18D. Predicted Breakthrough of pH
Lang Draw

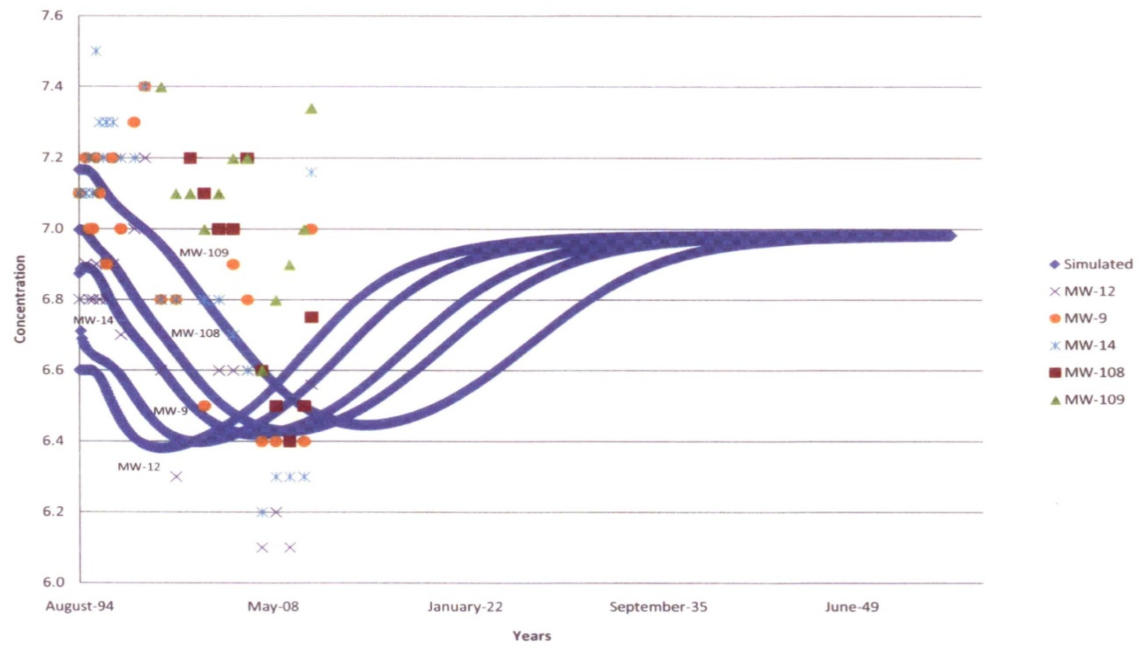


Figure 18E. Predicted Breakthrough of Radium Lang Draw

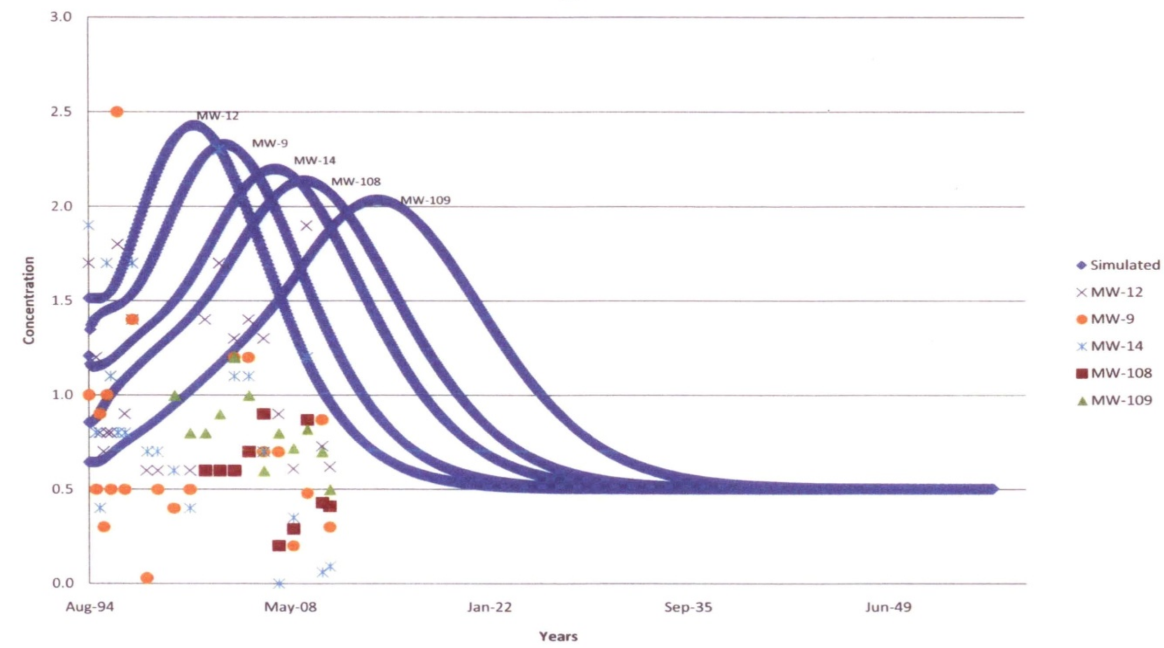
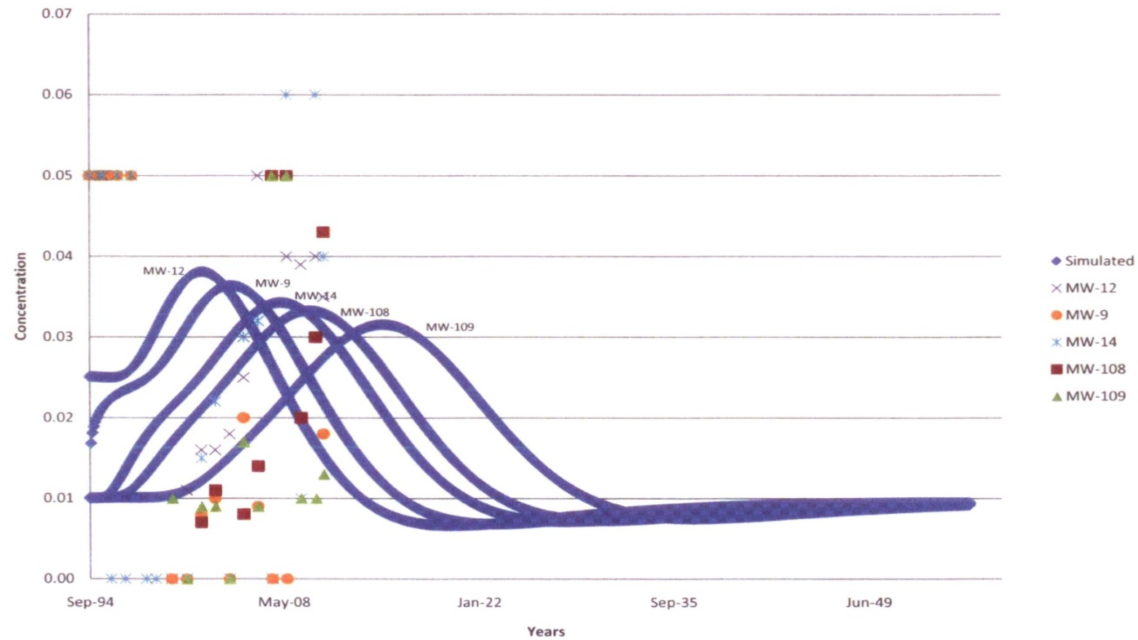
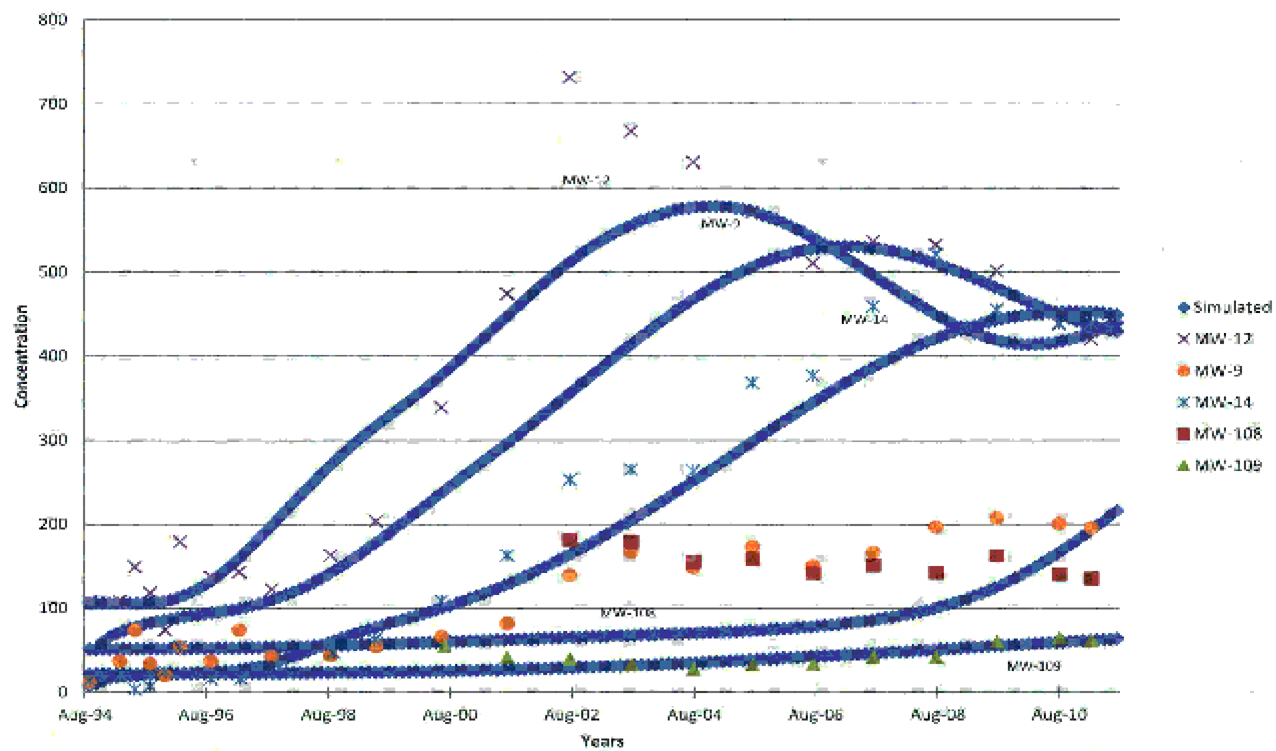


Figure 18F. Predicted Breakthrough of Nickel Lang Draw



FIGURES FROM 2012 MODELING

Figure 4. Comparison of observed and simulated concentrations of Uranium (pCi/L) along Lang Draw



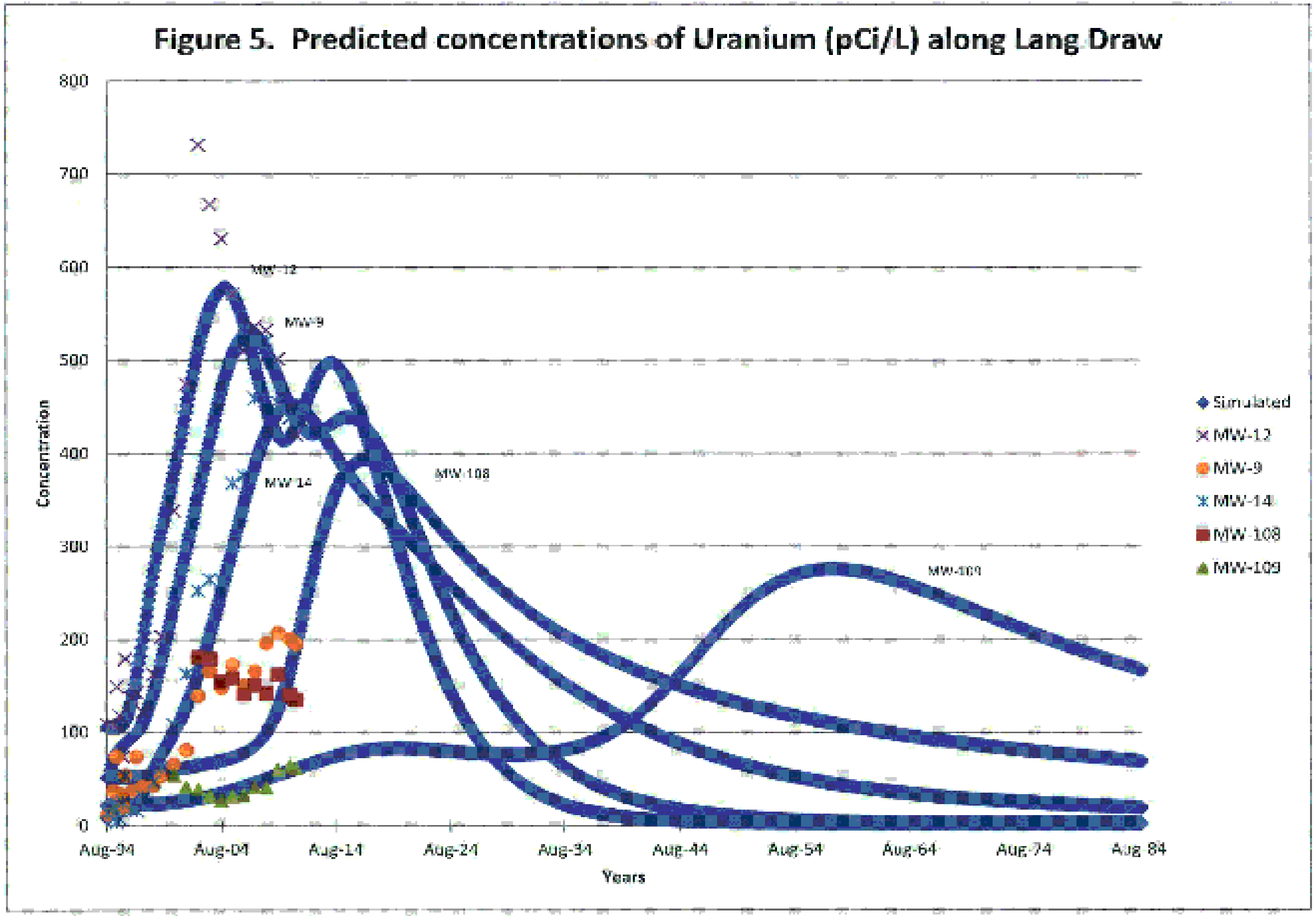


Figure 5. Predicted concentrations of Uranium (pCi/L) along Lang Draw
Concentration
800
700
600
500
400
300
200
100
0
Aug-94
Aug-04
Aug-14
Aug-24
Aug-34
Aug-44
Aug-54
Aug-64
Aug-74
Aug 84
Years
MW-12
MW-9
MW 14
MW 108
MW-109
Simulated
MW-12
MW-9
MW-14
MW 108
MW-109