UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 19, 2017

MEMORANDUM TO: Stephen S. Koenick, Chief
Materials Decommissioning Branch
Division of Decommissioning, Uranium Recovery, and Waste Programs
Office of Nuclear Material Safety and Safeguards

FROM: Matthew R. Meyer, Project Manager **/RA/**
Materials Decommissioning Branch
Division of Decommissioning, Uranium Recovery, and Waste Programs
Office of Nuclear Material Safety and Safeguards

SUBJECT: Summary of June 26 and 27, 2017 Meeting with Homestake Mining Company of California

On June 26 and 27, 2017, the U.S. Nuclear Regulatory Commission (NRC) staff met with representatives of the Homestake Mining Company of California (HMC) to discuss activities conducted in accordance with Confirmatory Order dated March 28, 2017.[1] These meetings were required by Conditions 8 and 10 of the above referenced Confirmatory Order.

Enclosed with this memorandum are the meeting summary with discussion items and presentations given to the NRC staff during this meeting.

DOCKET NO.: 040-08903

CONTACT: Matthew Meyer, NMSS/DUWP
(301) 415-6198

Enclosures:

1. Meeting Summary from Re-injection Program and Effluent Discharge Presentation
2. HMC Presentation: Analysis of the Impact of Exceedances of Ground-Water Protection Standards in Injection Water
3. HMC Presentation: Collection for Re-Injection Mass Balance/Removal Analysis

DISTRIBUTION:
DUWP r/f L. Gersey, RIV J. Whited, NMSS
ADAMS Accession No.: ML17352B067

OFFICIAL RECORD COPY

---

[1] Agencywide Document Access and Management System Accession No. ML17060A752.

Meeting Summary from Re-injection Program and Effluent Discharge Presentation
June 26 & 27, 2017

List of Attendees:

Name	**Affiliation**
John Tappert	NRC
Steve Koenick	NRC
Matthew Meyer	NRC
Michele Burgess	NRC
Ray Keller	NRC
Gerald George	Davis Wright Tremaine LLP
George Hoffman	Hydro-Engineering LLC
Thomas Michel	Hydro-Engineering LLC
Clark Burton	Barrick
Holton Burns	Barrick
Michael McCarthy	Barrick
Robert Lowry	Brown and Caldwell
Chuck Zimmerman	Brown and Caldwell

Collection for Re-Injection Mass Balance/Removal Analysis Presentation:

Mr. Thomas Michel from Hydro-Engineering, LLC, presented the slides for the Re-Injection impact analysis during the June 26th meeting. Mr. Michel provided an overview of the three main objectives of the program (Slide 3) that in summary included; (1) Collect and transfer impacted water from offsite to inside the hydraulic control area onsite, (2) Collect impacted water from inside the hydraulic control area and transfer to other areas within the hydraulic control area onsite; and (3) Allowed effective use of the RO treatment plant and evaporation ponds.

Collection wells used to supply the re-injection program were identified within five general areas (Slide 4). The five general collection areas used to supply impacted water for the re-injection program were the offsite L Collection Area and the S, C, K, and J Collection Areas located onsite and within the hydraulic control area. Collection from the L Area was shown to significantly reduce the uranium concentration within the L Area during the re-injection program.

A mass removal analysis of the L Collection Area was presented using available water quality data from 1996 through 2016 at 12 groundwater wells within the area of interest (Slide 9). The L Collection Area was subdivided into 12 smaller polygons using a grid-based overlay with an individual grid cell area of 2500 ft^2. Uranium concentrations from one well within each polygon were used to determine the mass of uranium in solution within each polygon on a yearly basis. The mass removal analysis for the L Collection Area indicates that the mass of uranium has been reduced since collection began and the estimated reduction in uranium mass between 1996 and 2015 was 4,282 lbs. (1,942 kg). A majority of the uranium mass removed was shown to occur prior to year 2000.

The impacts to the restoration time frame were evaluated by contrasting the program using two alternatives; (1) no collection for re-injection- L Collection Area wells not operating and (2) collection for re-injection water treated through reverse osmosis (RO) or discharged to evaporation ponds. Homestake's qualitative analysis of the impacts to the corrective action time frame based on the first alternative were determined to be a significant reduction in the time needed for remediation. This determination was based on an assumed expansion of the uranium plume at the L Collection Area if no pumping were to take place without the re-injection program. Additionally, the uranium transferred from the L Collection Area and re-injected onsite within the hydraulic control area was determined to be a very small fraction of the mass removed by collection from within the control area and the time frame for restoration within the hydraulic control area would not have been measurably reduced without the re-injection program. The second alternative was also determined to not have an impact on the corrective action restoration time frame. This determination was based on the reduced treatment of water containing higher concentrations of uranium if the impacted water containing lower concentrations of uranium in the L Collection Area was treated.

Discussion Items:

The U.S. Nuclear Regulatory Commission (NRC) staff commented that the impact analysis was highly focused on the L Collection Area rather than the impacts that may have occurred at the area depicted as the general area used for re-injection shown in slide 3. The corrective action program authorized by the NRC requires collection and treatment from impacted areas in order to achieve the estimated restoration schedule. In order to achieve the estimated restoration schedule, Homestake was already required to collect impacted water from the L Collection Area for treatment. The conclusions drawn from both assessed alternatives for the re-injection impact analysis were highly dependent on no collection taking place at the L Collection Area and the resulting expansion of the plume. While the staff agrees that the lack of collection would have resulted in an expansion of the plume, the “no action” alternative was not an option and therefore, collection from the L Collection Area should have occurred using one of the authorized methods regardless. Also, the second alternative concluded that the restoration time frame would have increased if the impacted water from the L Collection Area was transferred to either the RO plant or the evaporation ponds due to a reduction of higher impacted water being processed. The staff agrees that processing impacted water with lower concentrations would have increased the restoration time frame. However, the expected treatment rates for the RO plant were well below the expected 600 gpm of input water and approximately 420 gpm of product water due to deficiencies in the RO plant design. The RO plant was originally constructed with one 300 gpm low pressure unit followed by a high pressure unit to treat the brine from the low pressure unit. The design feed rate to the RO was limited to 300 gpm until 2002 when a second 300 gpm low pressure unit was installed, bringing the maximum RO feed rate to 600 gpm. Recent upgrades have further expanded the RO plant capacity to 1200 gpm. The RO plant should have been able to process the L Collection Area water and any deficiencies of the RO plant should have been corrected at that time. Additionally, evaporation/disposal capacity was significantly increased due to the addition of the second evaporation pond in March of 1996. Despite the addition of the second evaporation pond, total evaporation capacity continued to be a limiting factor in tailings dewatering rates and the evaporation/disposal of other collection waters. The staff commented that the re-injection impact analysis should have focused on the general area of re-injection to determine if there were any impacts to the corrective action restoration time frame based on the additional mass of uranium transferred to this area. A mass removal analysis for the re-injection area should be performed to show the mass of uranium over time and a comparison of the mass collected from the re-injection area to the mass of uranium transferred from the L Collection Area.

During a follow-up meeting on the June 27th, Homestake discussed the use of an alternative modeling approach to determine changes in the mass of uranium over time within the re-injection area. The alternate modeling approach will provide the necessary detail to determine if there are any impacts to the remediation time frame. The NRC staff agreed the modeling approach should provide the necessary detail to determine if any impacts occurred.

The proposed modeling approach uses commercial surface and volume analysis software (Quicksurf) to perform a mass balance analysis for the re-injection area. Quicksurf runs within AutoCAD and can utilize mapping with available concentration data, water-level elevation data, water-level elevation contours and iso-concentration contours to estimate contaminant mass. When compared with the polygon-based mass balance presented in the CAP, the Quicksurf analysis can utilize available concentration data from more wells and is not restricted to those wells selected to define the polygons. The Quicksurf analysis can also be more easily focused on the area of concern within the hydraulic control area. For these reasons, the Quicksurf analysis is expected to give a more refined mass balance in the re-injection area.

Analysis of the Impact of Exceedances of Ground-Water Protection Standards in Injection Water Presentation:

Mr. Thomas Michel from Hydro-Engineering, LLC, presented the impact analysis slides for the exceedances within effluent water from the RO plant used for groundwater injection during the June 26 meeting. The main objectives of the analysis was to determine what impact, if any, the exceedances may have had on the restoration process and in terms of human health and the environment.

Mr. Michel discussed the history of the RO plant and sampling from sampling point-2 (SP2). The exceedances observed at SP2 were defined in comparison to the current Groundwater Protection Standards (GWPSs) which distinguish between natural background and impacted groundwater. The magnitude and duration of the exceedances were evaluated to determine a period of time that had the potential to cause the greatest impact. The longest durations of exceedances were determined to have occurred during 2003 and 2004. The general area of water discharged from SP2 was shown to occur on the southern and eastern periphery of the Small Tailings Pile (STP). This area was partially within the hydraulic control area and just upgradient of the L Collection Area, which would have likely intercepted water that flowed to the south. Monitoring results from wells near the SP2 injection were evaluated and no impacts attributable to the exceedances of GWPSs at SP2 were determined.

Discussion Items:

The NRC staff did not have any items to discuss in further detail regarding the material presented. The presentation material indicates that the analysis will provide the level of detail necessary to evaluate any potential impacts due to the exceedances from the RO plant at SP2.

COLLECTION FOR RE-INJECTION MASS BALANCE/REMOVAL ANALYSIS

Report Objectives

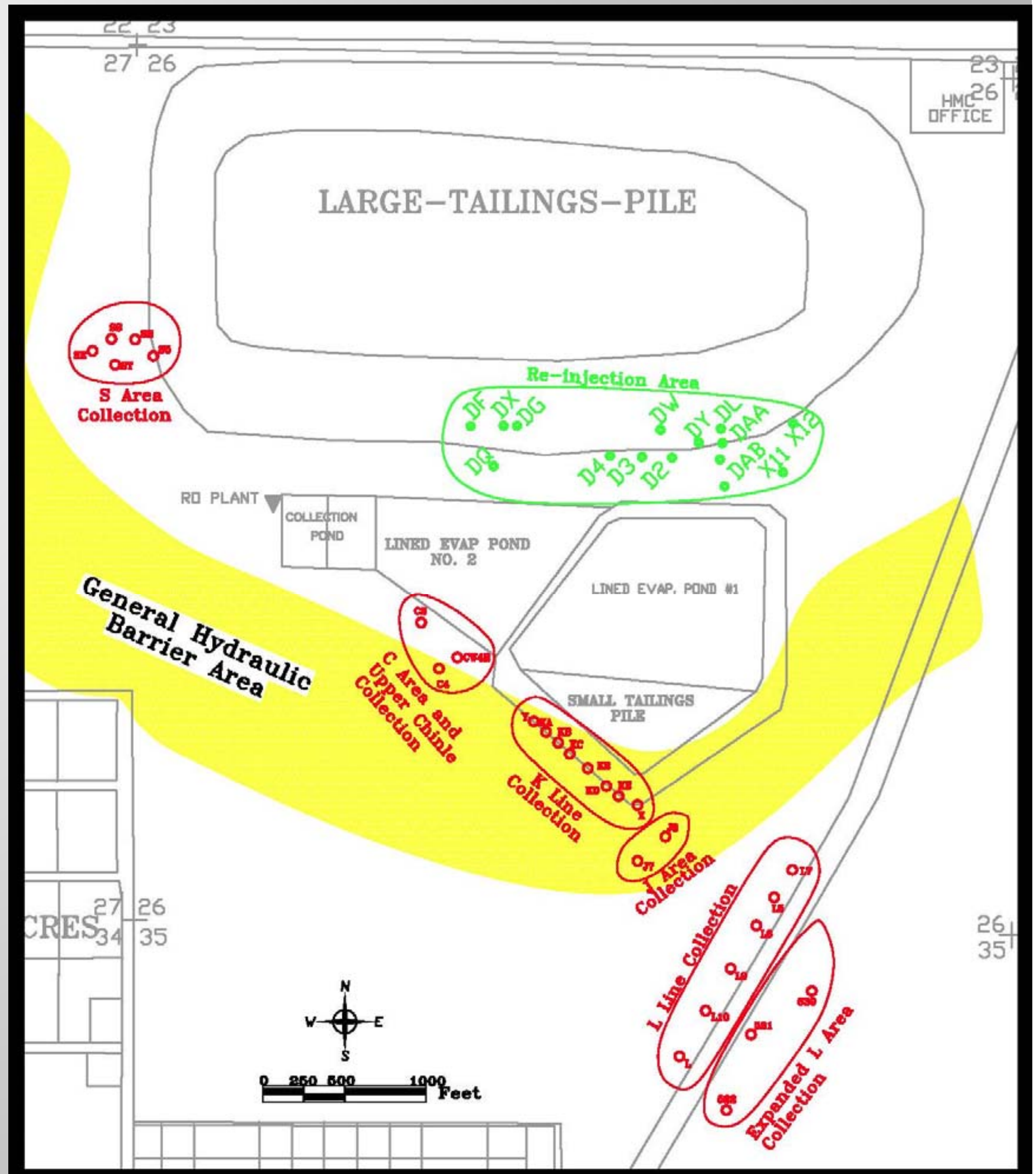
- The two primary objectives of conducting the analysis of the collection for re-injection program were as follows:
  - Evaluate the quantities of contaminants that were collected and transferred by collection for re-injection
  - Evaluate the impact of the collection for re-injection program on the restoration progress and timing

Collection for Re-injection History and Discussion

- The collection for re-injection program began in 1995 and continued through July of 2016
- The objectives of the collection for re-injection program were as follows:
  - Collect slightly to moderately impacted water from the L-Well area and transfer that water to inside the hydraulic control area
  - Collect moderately impacted water from *INSIDE* the hydraulic control area and transfer to other areas within the control area to increase gradients and improve restoration effectiveness
  - Allow the RO treatment and evaporation capacity to be used for more severely impacted ground water collected from wells within the control area

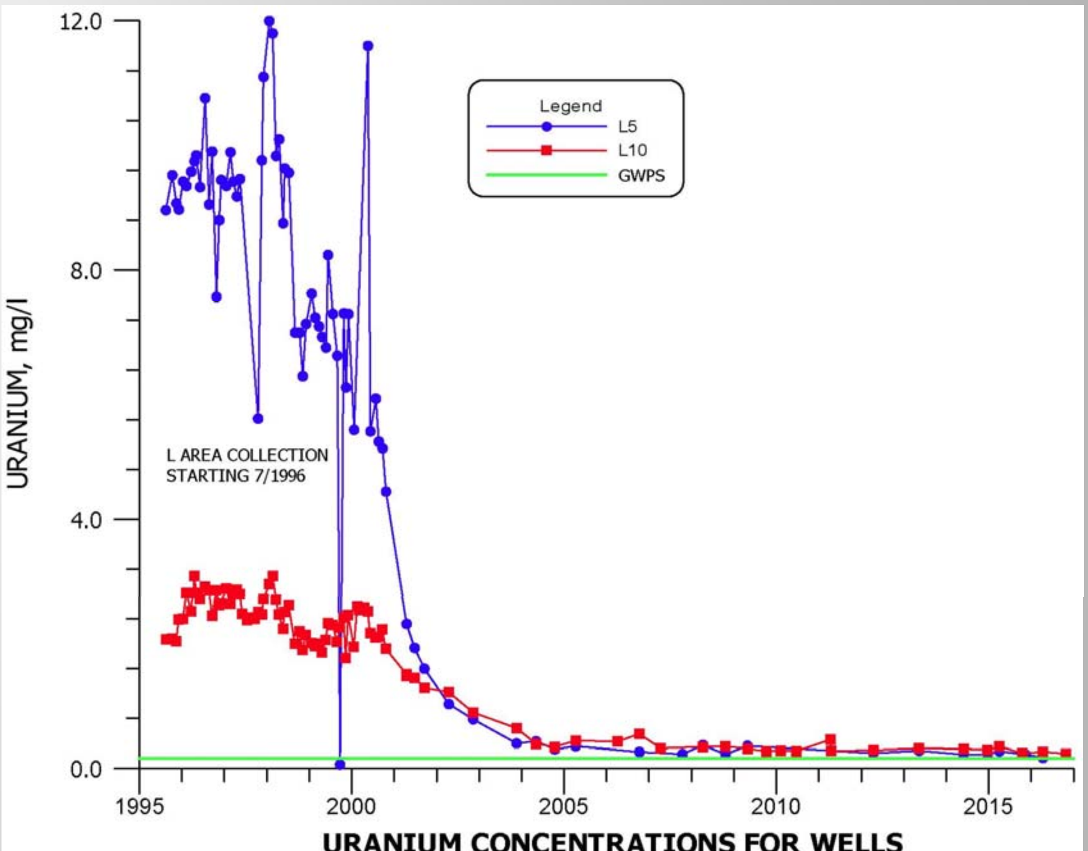
Collection Areas

- The collection occurred from five general areas
- The L Area collection wells are outside of the hydraulic control area
- The S, C, K and J Area wells are within the present hydraulic control area and were used to improve effectiveness of other collection operations within the hydraulic control area



L Area Restoration Progress

- The collection for re-injection program has resulted in significant reduction in uranium concentration in the L area
- A graph of measured uranium concentration in wells L5 and L10 illustrates the dramatic reduction in uranium concentration



URANIUM CONCENTRATIONS FOR WELLS L5 AND L10.

- The greatest reduction in uranium concentration occurred prior to 2002
- The uranium GWPS is 0.16 mg/l

Mass Balance/Removal Evaluation

- A mass removal evaluation based on that presented in the CAP was used to evaluate the collection for re-injection from the L Area
- The mass removal evaluation was done for uranium
- The S, C, K and J areas are internal to the hydraulic control and were not included in the mass removal analysis
- The mass balance within the hydraulic control area is discussed qualitatively due to the continuing source from the LTP

General Collection for Re-injection Scheduling

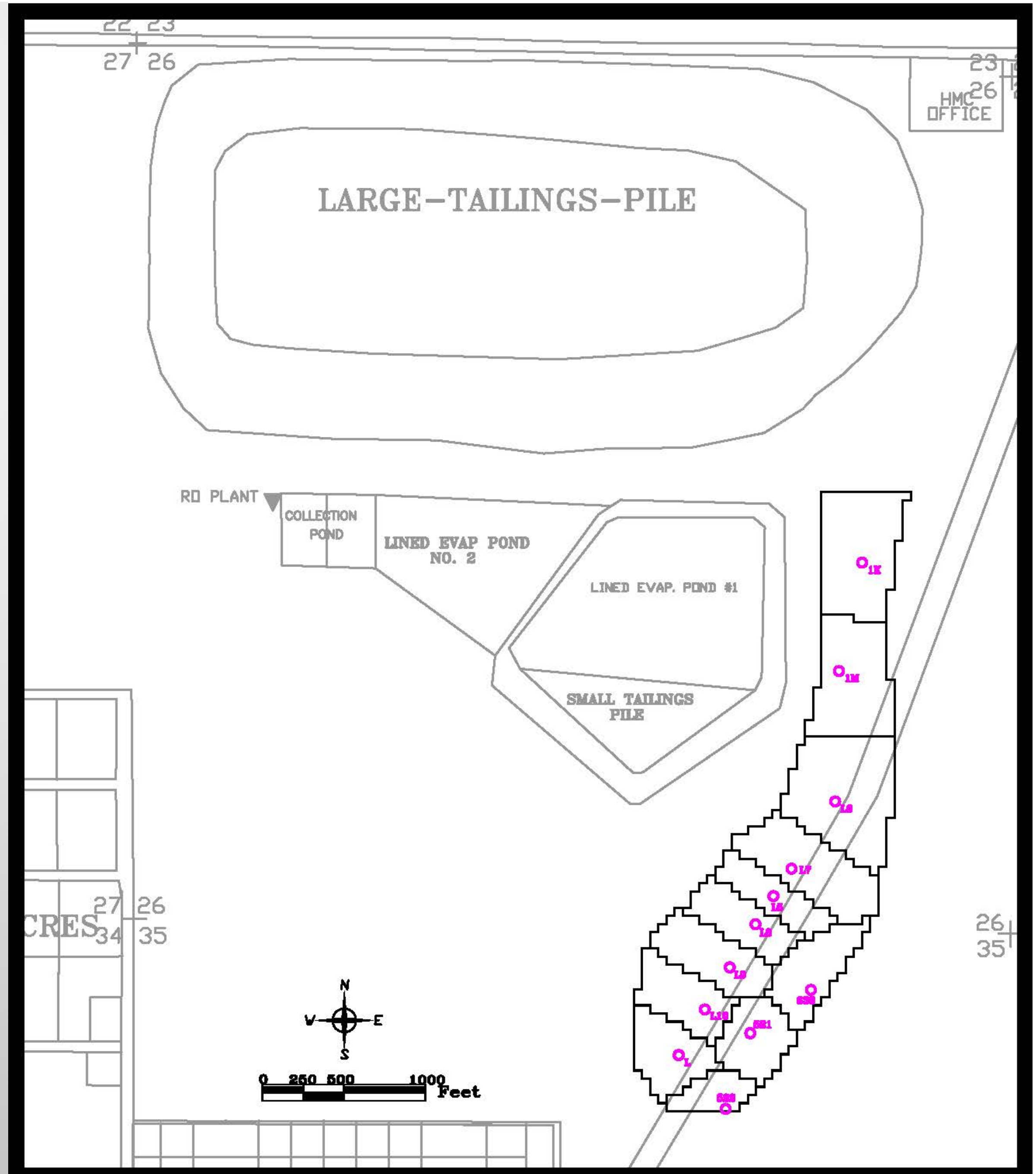
- The collection rate in 1995 was relatively small
- Based on available annual reports, collection in L area wells has occurred since 1996
- Collection from C area wells continued through 1998
- Collection from K area wells continued through 2001
- Collection from S area wells continued through 1999
- The collection from S, C, K and J areas transferred mass <u>within</u> the hydraulic control area
- The L area collection wells are outside of the hydraulic control area
- Only the collection from the L area wells is considered in the following mass removal analysis

Mass Removal Approach

- A boundary was drawn around the effective capture area for the L Area collection wells
- The available water quality data were reviewed and wells located within the area of interest were selected
  - The wells were selected based upon the water quality record and the distribution over the area of interest
  - It was necessary to extrapolate and/or interpolate from the water quality data for selected wells in order to span the analysis period from 1996 through 2016

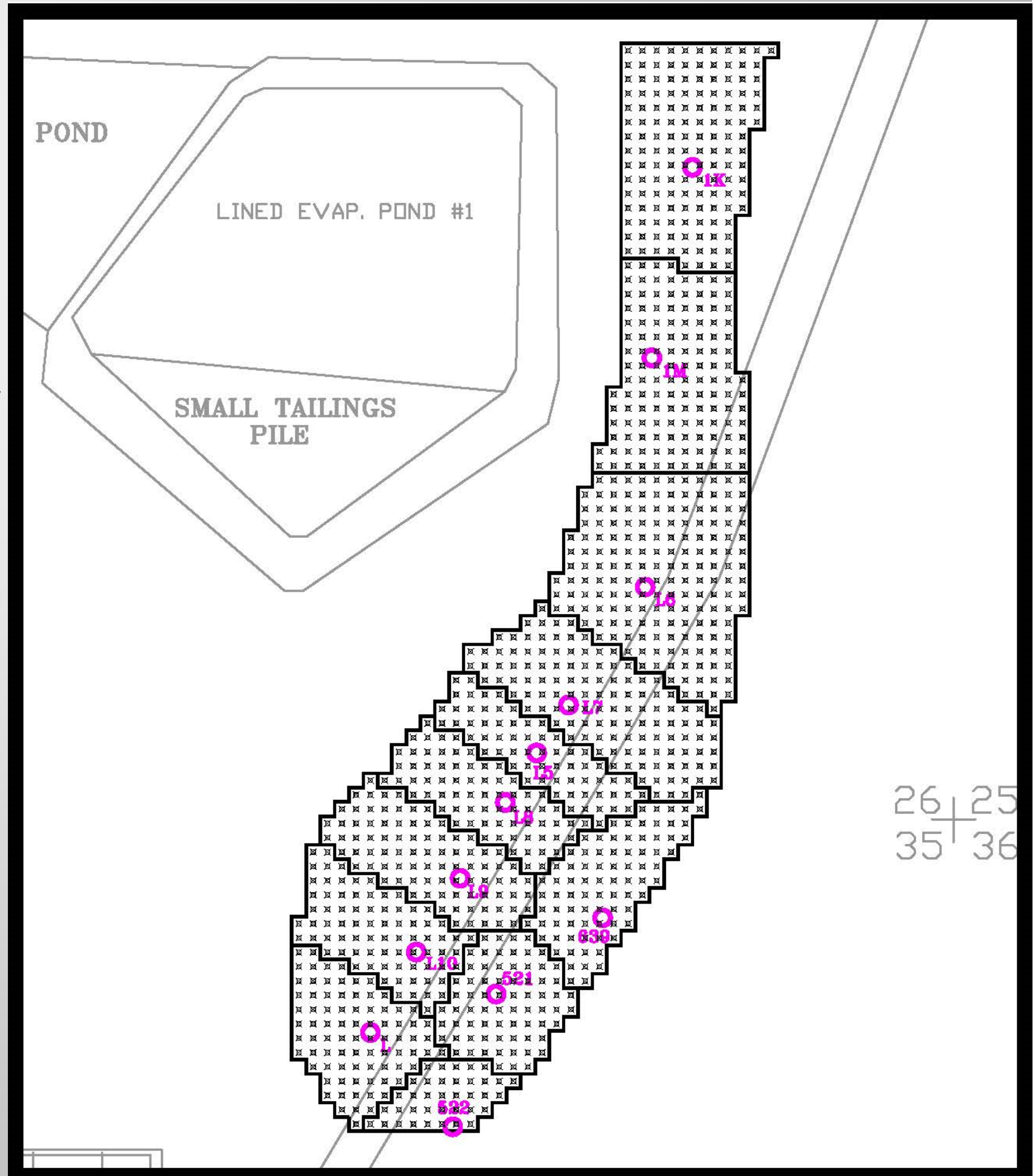
Selected Wells

- Twelve wells were selected for the mass removal analysis
- The wells included L Area collection wells and wells L6, 1M and 1K
- Wells 1M and 1K are north of the L collection wells and represent additional ground water that was likely captured by the collection



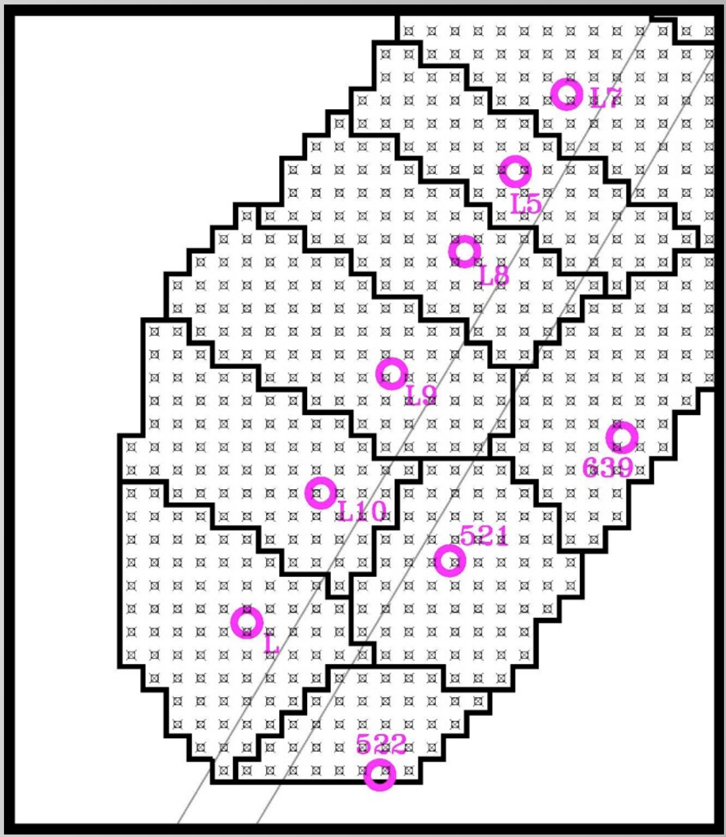
Polygon Definition

- The area of interest was subdivided into areas surrounding each well using a grid-based adaptation of the Theissen polygon method
- The polygons were developed using a 50′ x 50′ grid with each grid cell assigned to the closest well
- The L Area collection wells are outside of the hydraulic control area



Mass Computation

- The saturated thickness is calculated for each cell
- The saturated volume for each cell is the product of the cell area (2500 ft^2) and the saturated thickness
- The saturated alluvial volume for each well is the sum of the saturated volumes for each cell assigned to the well



- The measured uranium concentration for each well is tabulated for the period from 1996 through 2016
- If multiple samples were taken in one year, sample results were averaged to calculate a uranium concentration for each year
- Missing annual uranium concentration data were estimated using interpolation, extrapolation or comparison with nearby wells

Example Water Quality Tabulation

TABLE B.4-2 WATER QUALITY ANALYSES FOR HOMESTAKE'S ALLUVIAL WELLS (cont'd.)

pH THROUGH Th-230

Sample Point Name	Date	Lab	pH (std. units)	Unat (mg/l)	Mo (mg/l)	Se (mg/l)	NO3 (mg/l)	Ra226 (pCi/l)	Ra228 (pCi/l)	V (mg/l)	Th230 (pCi/l)
L	10/19/2000	ENER	---	1.58	---	0.0849	---	---	---	---	---
	4/17/2001	ENER	---	1.73	1.40	0.0330	---	---	---	---	---
	4/16/2002	ENER	---	1.55	1.40	0.0220	---	---	---	---	---
	11/18/2003	ENER	---	1.18	1.30	0.0530	2.00	---	---	---	---
	5/5/2004	ENER	---	0.769	---	0.0340	1.42	---	---	---	---
	10/14/2004	ENER	---	0.691	1.51	0.0320	---	---	---	---	---
	4/11/2005	ENER	---	0.690	---	0.0290	1.60	---	---	---	---
	4/6/2006	ENER	---	0.758	---	0.0530	1.50	---	---	---	---
	10/9/2006	ENER	---	0.553	1.50	0.0460	1.40	---	---	---	---
	4/11/2007	ENER	---	0.510	---	0.0440	1.40	---	---	---	---
	10/15/2007	ENER	---	0.355	0.960	0.0380	1.30	---	---	---	---
	10/21/2008	ENER	---	0.774	1.27	0.0640	1.54	---	---	---	---
	4/27/2009	ENER	---	0.496	---	0.0410	1.20	---	---	---	---
	10/6/2009	ENER	---	0.522	1.15	0.0470	1.30	---	---	---	---
	2/8/2010	ENER	7.45	0.447	1.17	0.0400	1.10	---	---	---	---
	6/22/2010	ENER	---	0.935	---	0.0620	1.40	---	---	---	---
	4/19/2011	ENER	---	0.592	---	0.0860	1.30	---	---	---	---
	4/13/2012	ENER	---	0.396	---	0.0340	1.000	---	---	---	---
	5/13/2013	ENER	---	0.510	---	0.0390	1.40	---	---	---	---
	5/29/2014	ENER	---	0.480	---	0.0410	1.30	---	---	---	---
	12/23/2014	ENER	---	0.449	0.620	0.0500	---	---	---	---	---
	4/2/2015	ENER	---	0.501	---	0.0640	1.60	---	---	---	---
	10/26/2016	ENER	---	0.375	0.460	0.0460	---	---	---	---	---
L5	1/9/1996	ENER	---	9.42	13.0	2.61	---	---	---	---	---
	2/8/1996	ENER	---	9.35	12.7	2.45	---	---	---	---	---
	3/19/1996	ENER	---	9.58	13.2	2.74	---	---	---	---	---
	4/17/1996	ENER	---	9.74	13.4	2.61	---	---	---	---	---
	5/1/1996	ENER	---	9.84	13.1	1.89	---	---	---	---	---
	6/3/1996	ENER	---	9.33	14.7	2.91	---	---	---	---	---

GWPS for uranium is 0.16 mg/l

Calculation

- The mass of uranium in solution in the area of interest is calculated as the zeroth spatial moment (M_0) presented in the CAP as:

$$M_0 = \sum_{i=1}^{N} b_i A_i C_i \; \Phi_i(x, y)$$

- N is the number of wells under consideration
- The term $b_i A_i$ represents the sum of saturated volume for each well described previously
- C_i is the uranium concentration in each well for the year of interest
- Φ is the effective porosity at each location (a value of 20 percent was used)

Uranium Concentration in L Area

The tabulation below presents the uranium concentrations by year for each of the selected L Area wells

Well	No. of Polygon	Composite Saturated	Uranium Concentration in Year (mg/l)																				
Name	Cells	Volume (ft^3)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
L	82	3,675,987	2.42	2.14	1.98	1.75	1.53	1.73	1.55	1.18	0.73	0.69	0.66	0.43	0.77	0.51	0.69	0.59	0.40	0.51	0.46	0.50	0.38
L5	63	1,944,308	8.62	9.22	8.84	6.55	6.18	1.95	0.91	0.40	0.37	0.36	0.27	0.23	0.30	0.36	0.32	0.28	0.24	0.28	0.23	0.25	0.17
L6	174	4,052,879	2.99	2.70	3.05	3.36	3.44	1.20	0.47	0.38	0.31	0.22	0.14	0.17	0.17	0.19	0.19	0.18	0.18	0.26	0.27	0.24	0.23
L7	122	3,331,662	7.08	3.67	3.73	3.79	3.85	2.19	0.94	0.49	0.41	0.27	0.30	0.22	0.21	0.22	0.18	0.17	0.16	0.21	0.25	0.28	0.26
L8	71	2,396,332	5.73	5.52	5.80	5.28	3.71	1.40	0.70	0.39	0.28	0.22	0.10	0.21	0.20	0.18	0.19	0.21	0.17	0.19	0.17	0.20	0.31
L9	88	3,295,154	3.78	4.07	3.78	3.08	3.06	1.44	0.74	0.40	0.30	0.24	0.21	0.23	0.25	0.20	0.15	0.23	0.35	0.29	0.26	0.24	0.21
L10	78	3,259,729	2.53	2.62	2.40	2.12	2.27	1.43	1.06	0.64	0.37	0.45	0.49	0.32	0.35	0.30	0.28	0.37	0.29	0.32	0.31	0.30	0.25
521	71	2,395,300	1.06	1.06	1.06	1.06	1.06	1.06	2.47	1.33	1.23	1.02	1.02	0.71	0.62	0.54	0.58	0.64	0.70	0.70	0.70	0.70	0.70
522	37	1,465,842	0.52	0.52	0.52	0.52	0.52	0.52	0.52	1.21	1.39	0.67	1.01	1.10	1.19	0.43	0.87	0.31	0.57	0.51	0.79	0.79	0.79
639	83	2,127,240	1.09	1.09	1.09	1.09	1.09	1.09	2.54	1.92	1.70	1.30	0.78	0.03	0.29	0.54	0.41	0.15	0.66	0.66	0.66	0.66	0.66
1K	143	3,061,968	5.78	10.1	43.5	22.7	12.6	2.58	2.12	3.61	2.39	1.47	1.62	1.85	7.65	6.16	4.66	3.17	1.67	1.46	1.24	1.03	0.81
1M	131	2,755,939	0.05	0.28	0.4	0.54	0.43	0.43	0.11	0.11	0.12	0.14	0.16	0.18	0.01	0.05	0.08	0.11	0.13	0.14	0.15	0.17	0.18

Red concentration values are interpolated or extrapolated from available data.

Blue concentration values are estimated from data for a nearby well.

Mass Balance/Removal Estimates

The tabulation below presents the estimated uranium mass present by year in the area of influence for each of the selected L Area wells

Well Name	No. of Polygon Cells	Composite Saturated Volume (ft^3)	Uranium Mass in Year (kg)																				
			1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
L	82	3,675,987	50	45	41	36	32	36	32	25	15	14	14	9	16	11	14	12	8	11	10	10	8
L5	63	1,944,308	95	102	97	72	68	21	10	4	4	4	3	3	3	4	4	3	3	3	2	3	2
L6	174	4,052,879	69	62	70	77	79	28	11	9	7	5	3	4	4	4	4	4	4	6	6	5	5
L7	122	3,331,662	134	69	70	71	73	41	18	9	8	5	6	4	4	4	3	3	3	4	5	5	5
L8	71	2,396,332	78	75	79	72	50	19	9	5	4	3	1	3	3	2	3	3	2	3	2	3	4
L9	88	3,295,154	70	76	71	57	57	27	14	7	6	4	4	4	5	4	3	4	7	5	5	4	4
L10	78	3,259,729	47	48	44	39	42	26	20	12	7	8	9	6	7	5	5	7	5	6	6	6	5
521	71	2,395,300	14	14	14	14	14	14	34	18	17	14	14	10	8	7	8	9	9	9	9	9	9
522	37	1,465,842	4	4	4	4	4	4	4	10	12	6	8	9	10	4	7	3	5	4	7	7	7
639	83	2,127,240	13	13	13	13	13	13	31	23	20	16	9	0	3	7	5	2	8	8	8	8	8
1K	143	3,061,968	100	175	754	394	218	45	37	63	41	25	28	32	133	107	81	55	29	25	22	18	14
1M	131	2,755,939	1	4	6	8	7	7	2	2	2	2	3	3	0	1	1	2	2	2	2	3	3
		Sum (kg)	675	688	1265	859	658	282	220	187	142	107	102	87	196	160	138	107	85	87	84	81	73
		Sum (lb)	1485	1513	2782	1890	1447	620	485	412	313	235	224	191	431	351	304	235	188	191	184	178	162

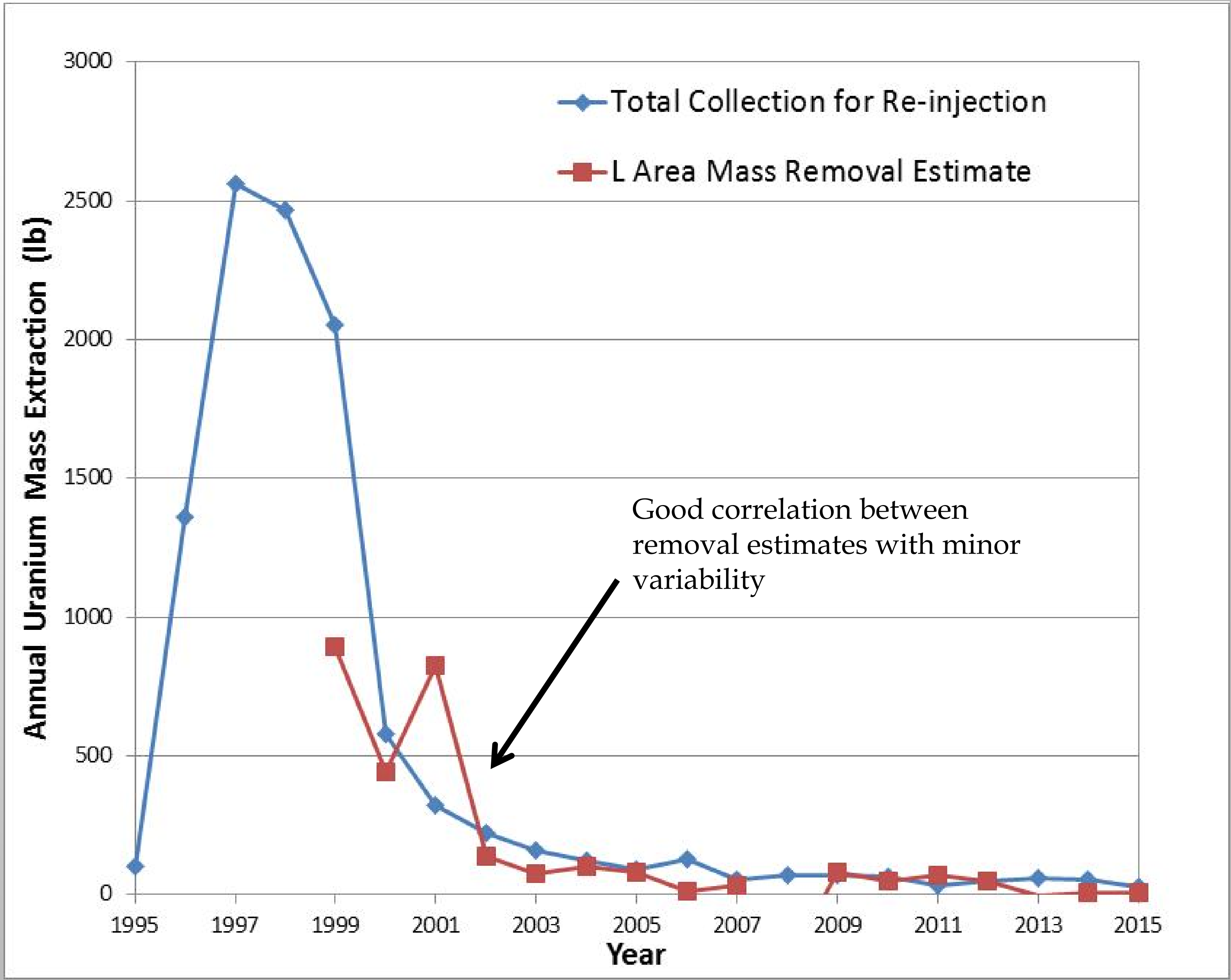
Mass Balance/Removal Discussion

- The preceding tabulation indicates that the mass of uranium in the area of interest has been reduced since collection began
- The greatest uranium mass was in 1998, estimated at 1,265 kg or 2,782 lbs
- The estimated uranium mass in 2015 was 81 kg or 178 lbs
- The estimated reduction in uranium mass between 1998 and 2015 was 1,184 kg or 2,604 lbs
- The uranium mass removed in 1996 and 1997 was estimated at 1,678 lbs using average concentrations and assumed L area collection rates

Comparison with Total Collection for Re-injection Capture

- The collection for re-injection program operated at collection rates ranging from 25 gpm to 108 gpm through 2015
- The average uranium concentration in the collection water ranged from 0.27 mg/l to 5.92 mg/l through 2015
- The majority of the mass extraction or capture occurred prior to year 2000 with the operation of C, S, and K area wells along with the L area wells
- Because the uranium mass extracted from the C, S and K area wells came from and remained within the hydraulic control area, it did not increase the mass within the hydraulic control area
- The mass extracted by the collection for re-injection wells is extremely small in comparison to the residual mass within the hydraulic control area (estimated at 72,094 lbs in 2015) or the mass entering the alluvial aquifer from seepage from the LTP (estimated at 2,389 lbs in 2015)
- The following graph illustrates the calculated capture by the collection for re-injection program and the estimated mass removal from the L area

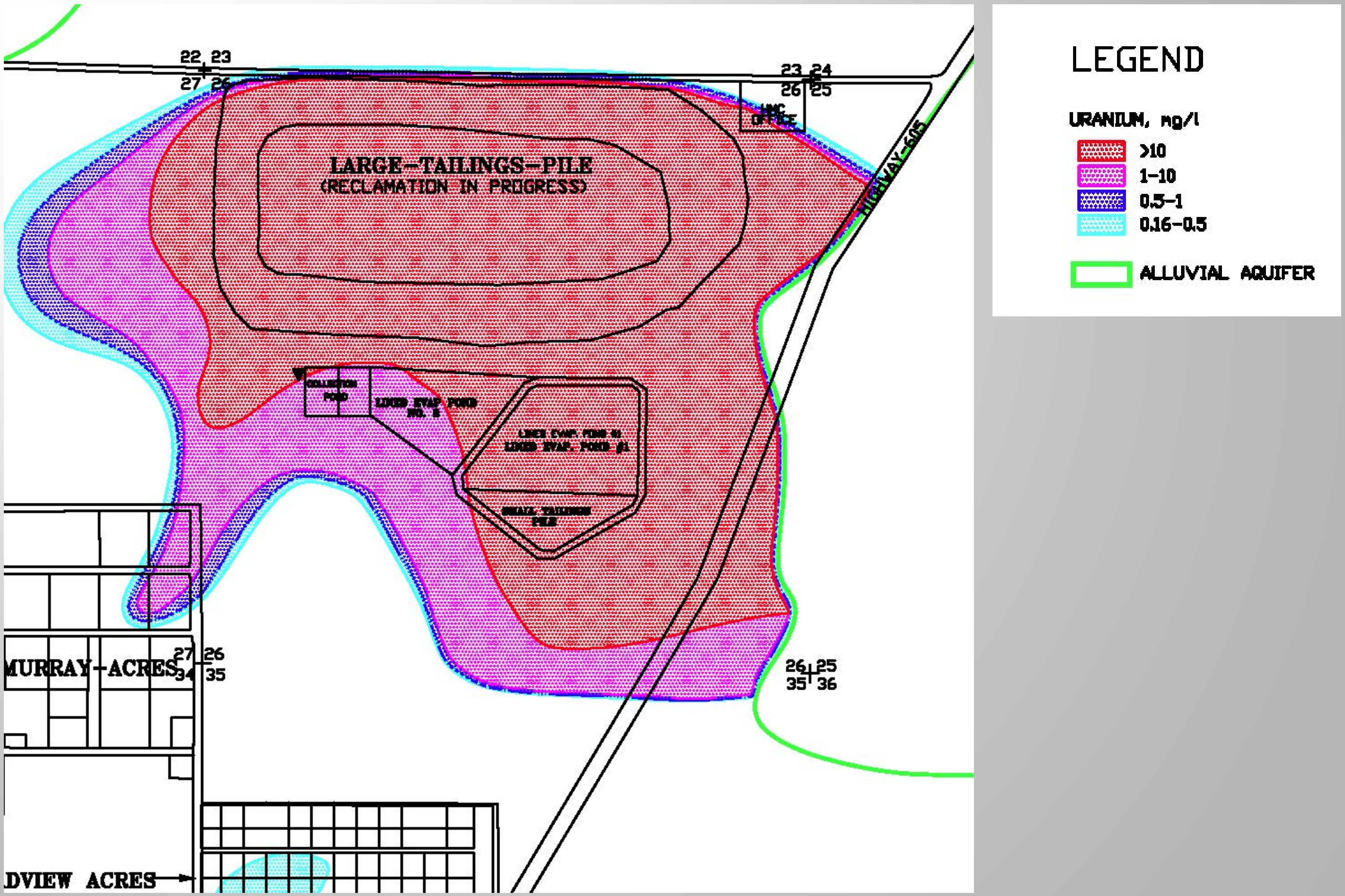
Mass Extraction/Removal Comparison



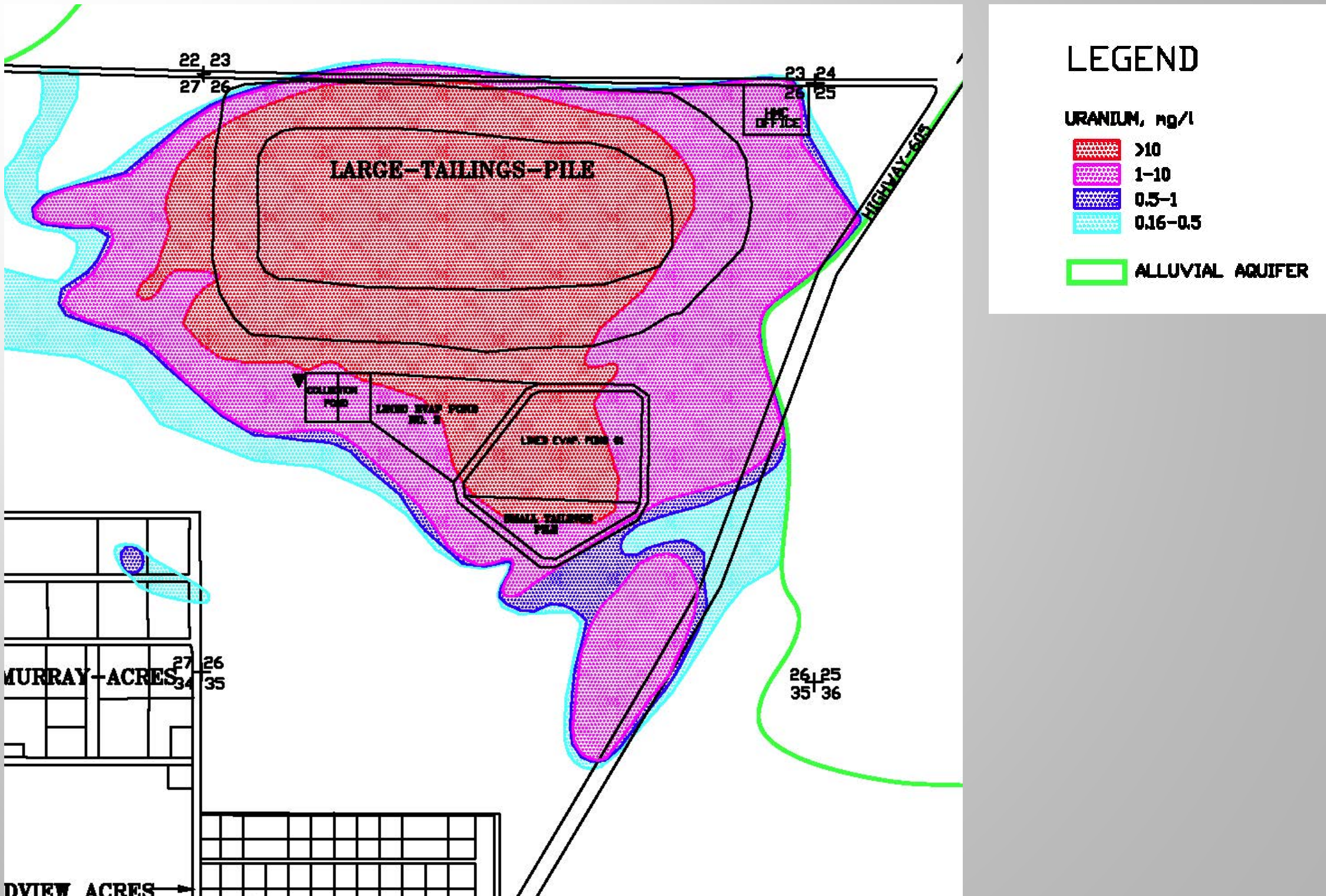
Mass Comparison

- Using the maximum estimated uranium mass of 2,782 for the L area in 1998, the estimated removal through 2015 is 2,604 lb
- Combined with an estimated removal of 1,678 lbs in 1996 and 1997, the total estimated L area removal is 4,282 lbs
- Additional mass collected from the S, C, K and J wells was relocated within the hydraulic control area
- The majority of the extraction occurs prior to year 2000
- The following maps illustrate the reduction in L area plume extent and concentration from that prior to collection for re-injection through 2016

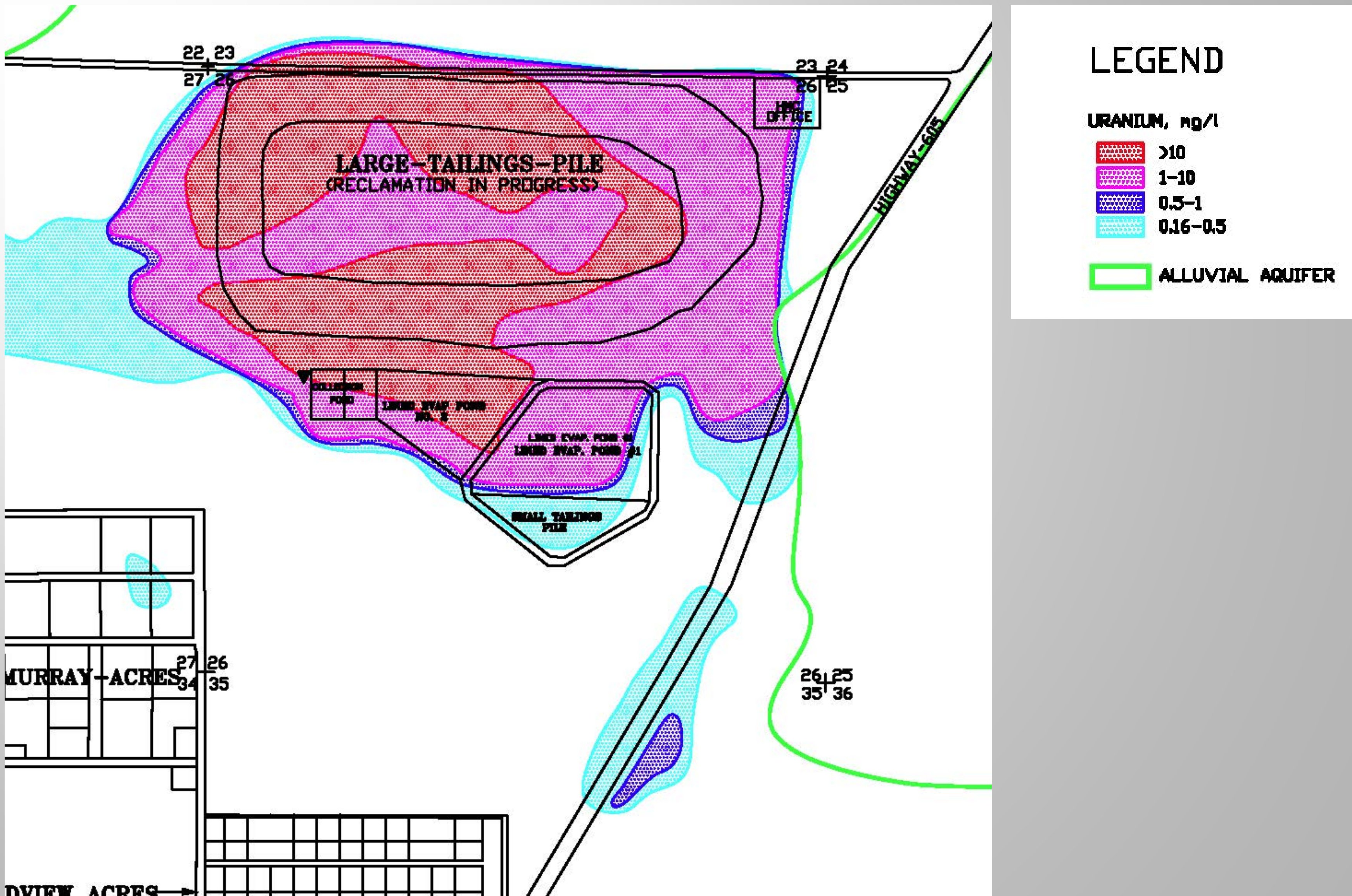
Uranium Concentration in the LTP Area - 1988



Uranium Concentration in the LTP Area - 1999



Uranium Concentration in the LTP Area - 2013



Uranium Concentration in the LTP Area - 2016

Comparison with Mass Exchange Within Hydraulic Control Area

- During the period of interest, the uranium removal by RO treatment and evaporation is estimated at over 340,000 lbs with the vast majority extracted from within the hydraulic control area
- Seepage from the LTP is a continuing source (at diminishing rate) of uranium to the alluvial aquifer in the control area
- The tabulation below presents example annual uranium mass transfer calculations in seepage from the LTP

Example Seepage Rate (gpm)	Example Uranium Concentration in Seepage (mg/l)	Annual Uranium Mass Transfer (kg)	Annual Uranium Mass Transfer (lb)
180	40	14,335	31,603
150	30	8,959	19,752
100	20	3,982	8,779
50	10	995	2,195
25	5	249	549

Impacts to Restoration Time Frame

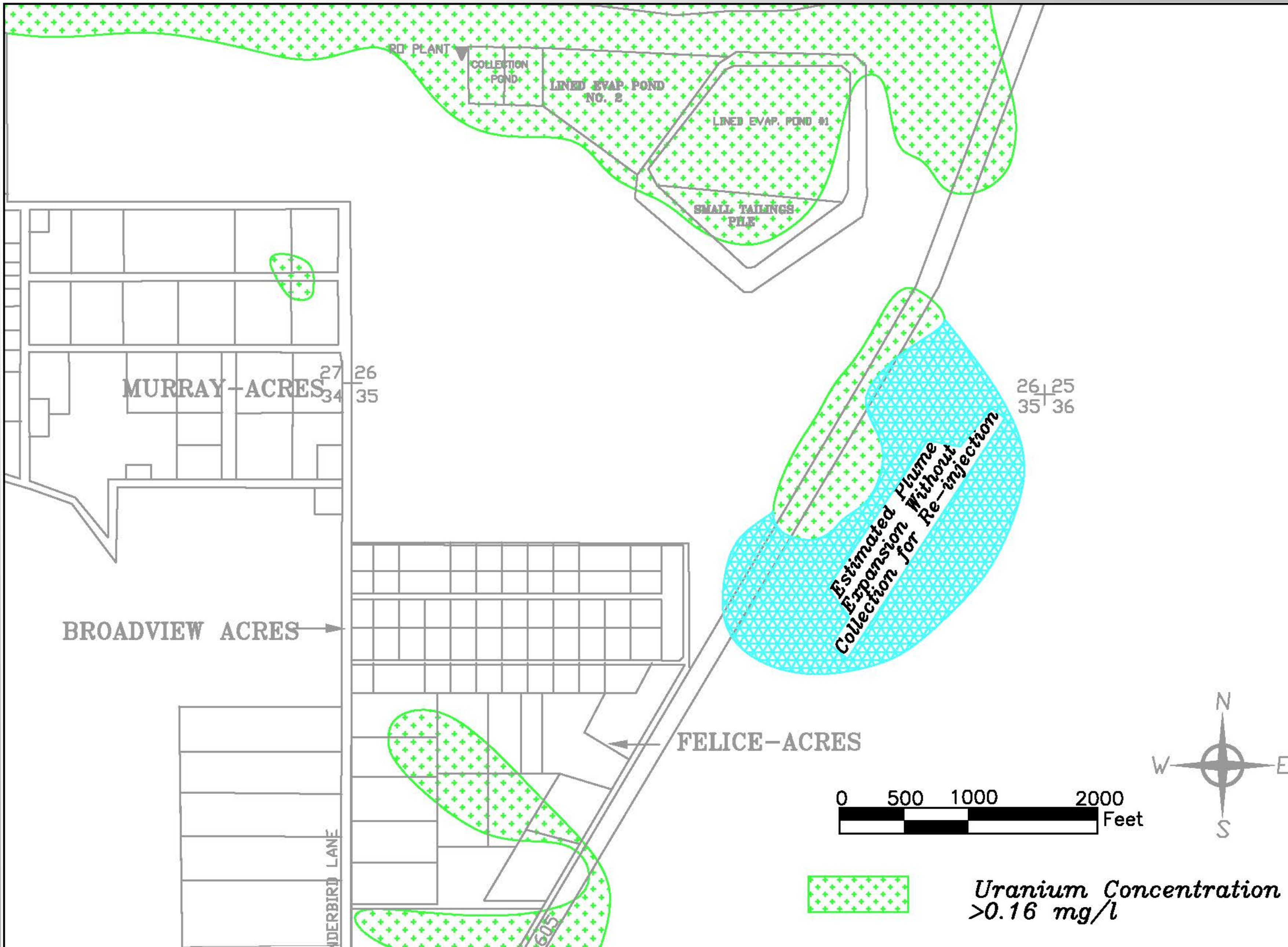
- The impact to the restoration time frame resulting from the collection for re-injection program is evaluated by contrasting the program with the following alternatives:

1. <u>No Collection for Re-injection </u>- L area collection wells not operated
2. <u>Collection for Re-injection water treated through RO or discharged to evaporation</u>

Impacts – Alternative #1 – No Collection for Re-injection

- Benefits/Advantages
  - No additional uranium mass (estimated at 4,282 lbs) would have been transferred from L area to within the hydraulic control area
  - No water treatment or evaporation capacity would have been potentially diverted from the higher priority needs within the hydraulic control area
- Detriments/Disadvantages
  - The size of the impacted plume area near the L wells would have continued to increase until collection was initiated
  - The plume area would have potentially reached non-HMC property where it affects other landowners
  - If the plume reached non-HMC property, access for restoration activities would likely have been limited
  - The volume of ground water requiring restoration would likely have been increased by a factor of three or more due to uncontrolled plume expansion in the L area
  - With the same uranium mass distributed through a much larger volume of ground water, the efficiency of the uranium removal by water treatment would have been dramatically reduced
- Time Frame Impacts
  - The time frame for restoration of the expanded plume in the L area would have been significantly increased because a much larger volume of ground water would have required treatment
  - The uranium mass transferred from the L area into the hydraulic control area is a very small fraction of the mass removed by collection from the control area – therefore the time frame for restoration within the hydraulic control would not have been measurably reduced had the collection for re-injection not occurred

Estimated Plume Expansion for Alternative #1 Based on Current Plume Extent



Impacts – Alternative #2 – Treatment or Evaporation of Collection for Re-injection Waters

- Benefits/Advantages
  - No additional uranium mass (estimated at 4,282 lbs) would have been transferred directly from L area to within the hydraulic control area
- Detriments/Disadvantages
  - With a fixed water treatment and/or evaporation capacity, a significant portion of the collection well operation inside the hydraulic control area would have been sacrificed to allow treatment of L area collection waters
  - The mass of uranium removed by RO treatment or evaporation would have been reduced because the uranium concentration in the treatment feed stream would have been reduced
  - Benefits of using re-injection to drive higher concentration ground water to collection wells would not have been realized
- Time Frame Impacts
  - Because the uranium concentration in the L area wells was typically a factor of 5 to 10 times smaller than that in collection wells within the hydraulic control area, devoting part of the finite treatment/evaporation capacity to the L area collection water would have significantly reduced the mass of uranium removed by treatment or evaporation. Thus, this alternative would have increased the time required for restoration.
  - The time frame for restoration of the plume in the L area would have been largely unchanged

Summary

- The collection for re-injection program was successful in controlling the plume and reducing the uranium mass in the L area
- The uranium mass extracted from the L area was very small in comparison to the ongoing mass exchange and/or removal occurring within the hydraulic control area
- The collection for re-injection program effectively reduced the time required for ground-water restoration by controlling the plume in the L area without compromising restoration activities within the hydraulic control area

END

ANALYSIS OF THE IMPACT OF EXCEEDANCES OF GROUND-WATER PROTECTION STANDARDS IN INJECTION WATER

Report Objectives

- The primary objective of conducting the analysis of exceedances of GWPSs at SP2 is to determine
  - what impact, if any, the exceedances may have had on restoration progress
  - what impact, if any, the exceedances may have had in terms of human health and the environment
- A significant impact would be an increase in COC concentration in ground water to levels greater than the corresponding GWPS, that is attributable to the exceedances in injection water represented by SP2
- The exceedances of GWPSs at SP2 addressed in this analysis were noted as occurring through 2014 in an October 4, 2016 letter from NRC to HMC
- In addition, a few subsequent exceedances were noted in NRC's 2016 inspection, and are also considered in this report.

RO and SP2 Sampling History and Discussion

- The RO plant began operation in 1999
- SP2 was established as the licensed sampling point for the combination of RO product water and fresh water that was injected into the ground water inside the hydraulic barrier
- Two separate injection water distribution systems existed during the period of interest
  - One injection distribution system was used for supplying SP2 water to injection wells located primarily on the south and east periphery of the small tailings pile (STP)
  - The other injection distribution system supplied fresh water from the San Andres aquifer to the remaining injection wells and infiltration lines
- The sample location SP1 represents the RO product water and is not representative of injected water

Defining Exceedances

- The current GWPS is the background ground water standard set in 2006
  - uranium GWPS is 0.16 mg/l
  - molybdenum GWPS is 0.10 mg/l
- Prior to the establishment of background GWPSs in 2006, the GWPS for uranium was 0.04 mg/l and the GWPS for molybdenum was 0.03 mg/l
- The current GWPSs are used for defining an exceedance warranting evaluation because:
  - Current GWPSs distinguish between natural background and impacted ground water
  - The older GWPSs have been superseded by the current GWPSs

Exceedances of Current GWPSs at SP2

Sample Location	Date	Uranium (mg/L)	Molybdenum (mg/L)	Notes
RO SP2	3/21/2001	--	0.1382	
	15 Months			
RO SP2	7/16/2002	--	0.11	
	6 Months			
RO SP2	2/18/2003	--	0.11	Longest Continuous Period of Exceedance of GWPS for Molybdenum
RO SP2	3/10/2003	--	0.13	
RO SP2	4/21/2003	--	0.12	
RO SP2	5/13/2003	--	0.164	
RO SP2	6/24/2003	--	0.18	
RO SP2	7/15/2003	--	0.13	
RO SP2	8/12/2003	--	0.21	
RO SP2	9/19/2003	--	0.11	
RO SP2	10/9/2003	--	0.23	
RO SP2	11/11/2003	--	0.38	
RO SP2	12/9/2003	--	0.18	
RO SP2	1/14/2004	--	0.143	
	9 Months			
RO SP2	11/17/2004	0.369	0.72	Greatest Exceedance
	36 Months			
RO SP2	12/10/2007	--	0.12	
	14 Months			
RO SP2	3/5/2009	--	0.19	
	11 Months			
RO SP2	3/3/2010	0.165	0.24	
	14 Months			
RO SP2	6/10/2011	--	<0.03*	Duplicate Sample
RO SP2	6/10/2011	--	0.11	

Sample Location	Date	Uranium (mg/L)	Molybdenum (mg/L)	Notes
	5 Months			
RO SP2	12/5/2011	--	0.07*	Two Samples
RO SP2	12/8/2011	--	0.12	
	4 Months			
RO SP2	5/1/2012	--	0.07*	Two Samples
RO SP2	5/18/2012	--	0.11	
	1 Month			
RO SP2	7/2/2012	--	0.172	
RO SP2	8/7/2012	--	0.32	
RO SP2	9/13/2012	--	0.11	
	1 Month			
RO SP2	11/8/2012	--	0.12	
	13 Months			
RO SP2	1/21/2014	--	0.117	
	9 Months			
RO SP2	11/5/2014	--	0.11	
	1 Month			
RO SP2	1/13/2015	0.164	0.14	
	3 Months			
RO SP2	5/27/2015	--	0.28	
	2 Months			
RO SP2	8/5/2015	--	0.162	
RO SP2	9/17/2015	0.247	0.23	Duplicate Sample
RO SP2	9/17/2015	0.278	0.25	
RO SP2	10/6/2015	--	0.14	Duplicate Sample
RO SP2	10/6/2015	--	0.14	

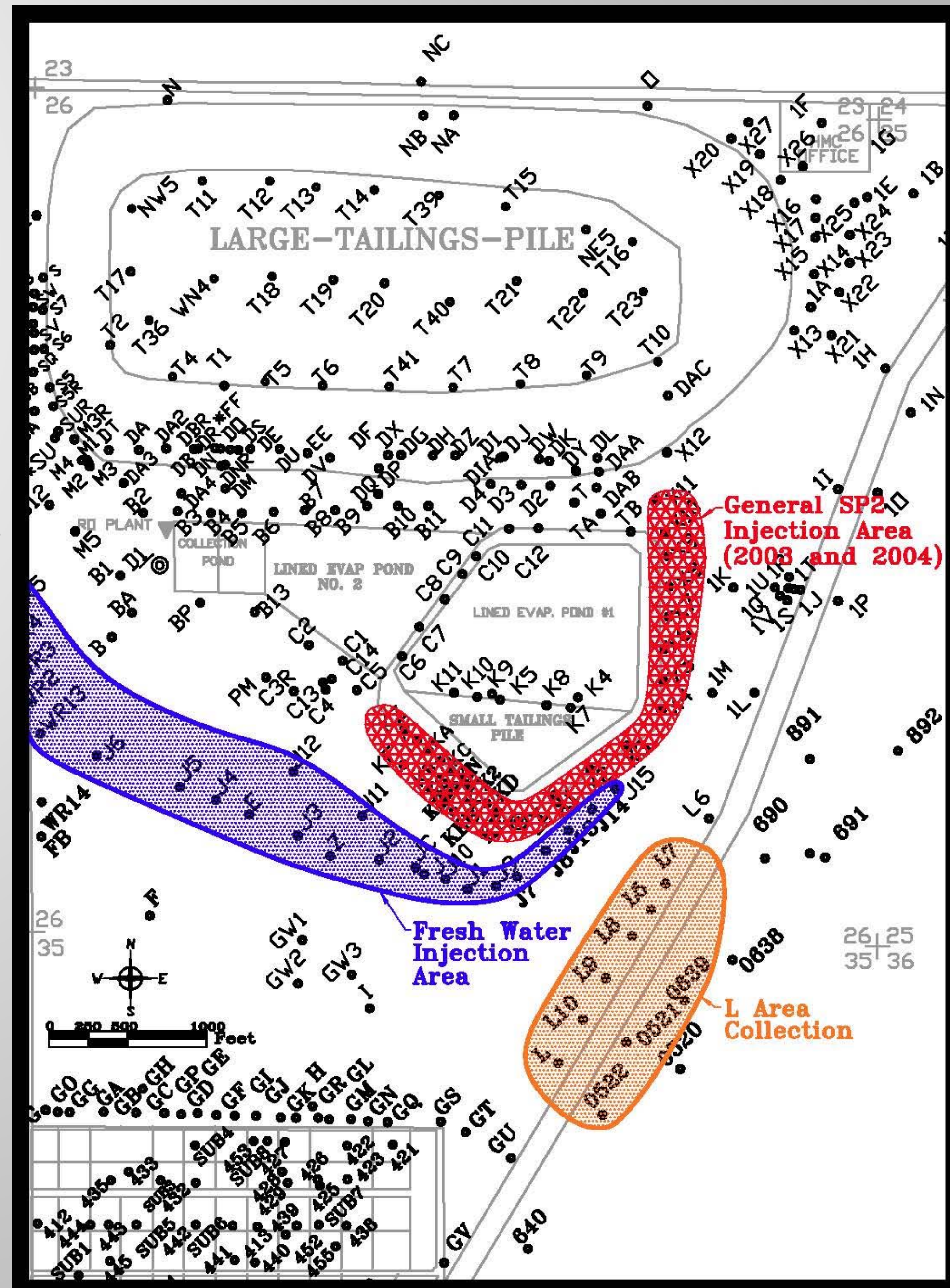
* Duplicate or multiple monthly sample not in exceedance of GWPS

Magnitude and Duration of Exceedances

- The excess mass of the COC injected with the SP2 water depends on both the duration of the exceedance and COC concentration in excess of the GWPS
  - The exceedance period is assumed to begin at the start of the month of detection, and to end at the end of the last month of continuous exceedance
- The longest duration exceedance of the molybdenum GWPS of 0.10 mg/l occurred from Feb. 2003 thru Jan. 2004
- The largest magnitude exceedance of the molybdenum GWPS of 0.10 mg/l occurred in November of 2004
- The largest magnitude exceedance of the uranium GWPS of 0.16 mg/l occurred in November of 2004
- The longest exceedance duration for molybdenum and the largest magnitude exceedance for both molybdenum and uranium are evaluated to represent the maximum potential impacts
- Other exceedances, including minor exceedances in 2015, are much less significant because of shorter duration and/or lesser magnitude
- Exceedances in the period from Aug. 2015 thru Oct. 2015 occurred during expanded RO plant construction and represent a transitional or limited treatment plant operation

SP2 Injection and Mitigating Factors

- The SP2 injection in 2003 and 2004 occurred on the southern and eastern periphery of the STP
- Fresh water was injected in a line of wells to the south of the SP2 injection area
- The fresh water injection acts to push the SP2 injection water inward towards the STP
- The collection in the L area would likely intercept SP2 injection water that flowed to the south



Injection Rates Reported in 2004 Annual Report

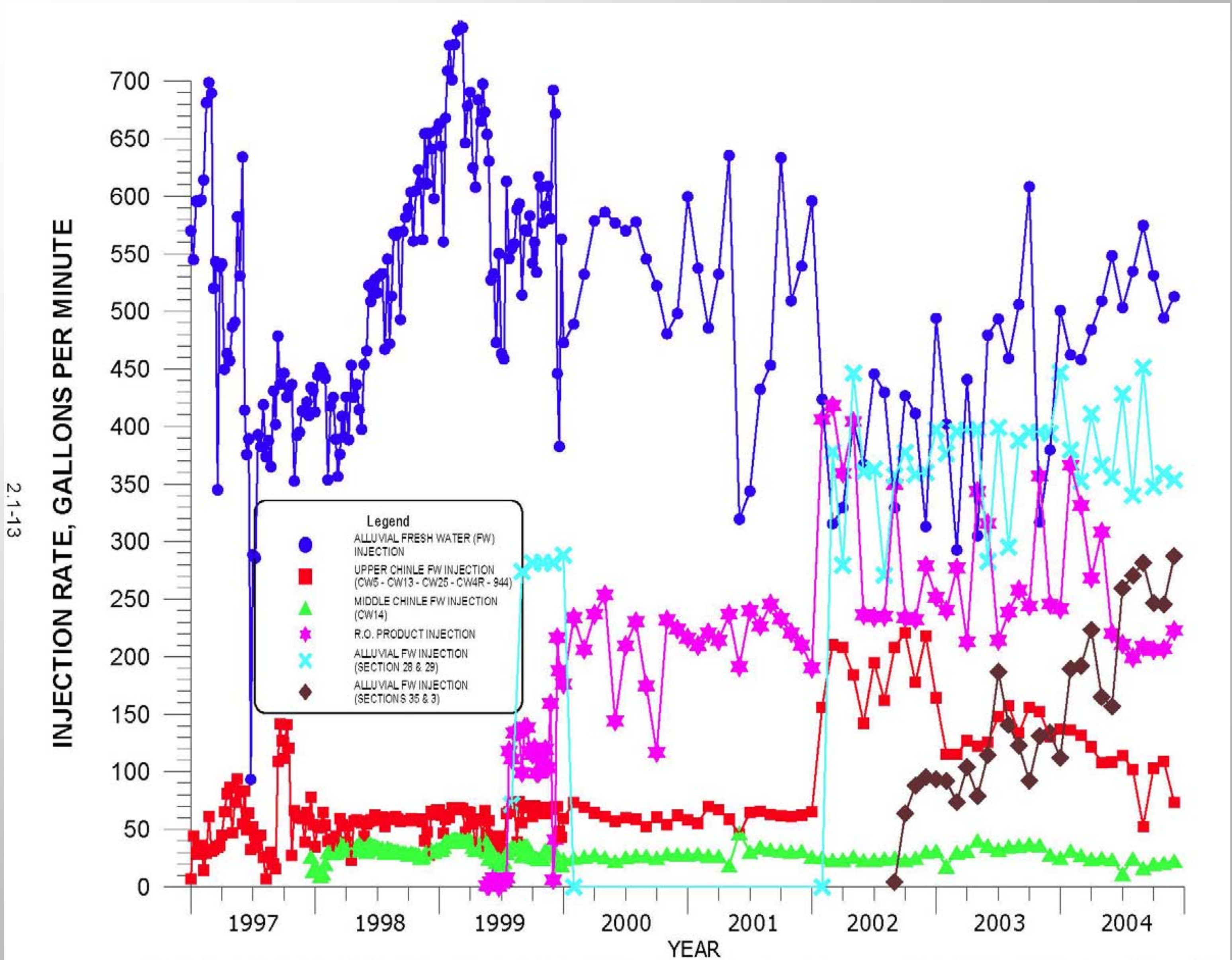


FIGURE 2.1-3. AVERAGE MONTHLY INJECTION RATES FOR THE ALLUVIAL UPPER CHINLE AND MIDDLE CHINLE AQUIFERS.

Injection Rates and Concentrations During Exceedances

- The injection rate for SP2 water from Feb. 2003 thru Jan. 2004 was estimated at 365 gpm with 265 gpm of RO product and an estimated fresh water addition of 100 gpm
- The range of molybdenum concentrations from Feb. 2003 thru Jan. 2004 was 0.11 to 0.38 mg/l with an average of 0.174 mg/l
- The exceedance of the GWPS of 0.10 mg/l by 0.074 mg/l was used in evaluating the impacts
- The injection rate for SP2 water in Nov. 2004 was estimated at 349 gpm with 249 gpm of RO product and an estimated fresh water addition of 100 gpm
- The molybdenum concentration in Nov. 2004 was 0.72 mg/l which exceeded the GWPS of 0.10 mg/l by 0.62 mg/l
- The uranium concentration in Nov. 2004 was 0.369 mg/l which exceeded the GWPS of 0.16 mg/l by 0.209 mg/l

Excess Mass Injected During Exceedances

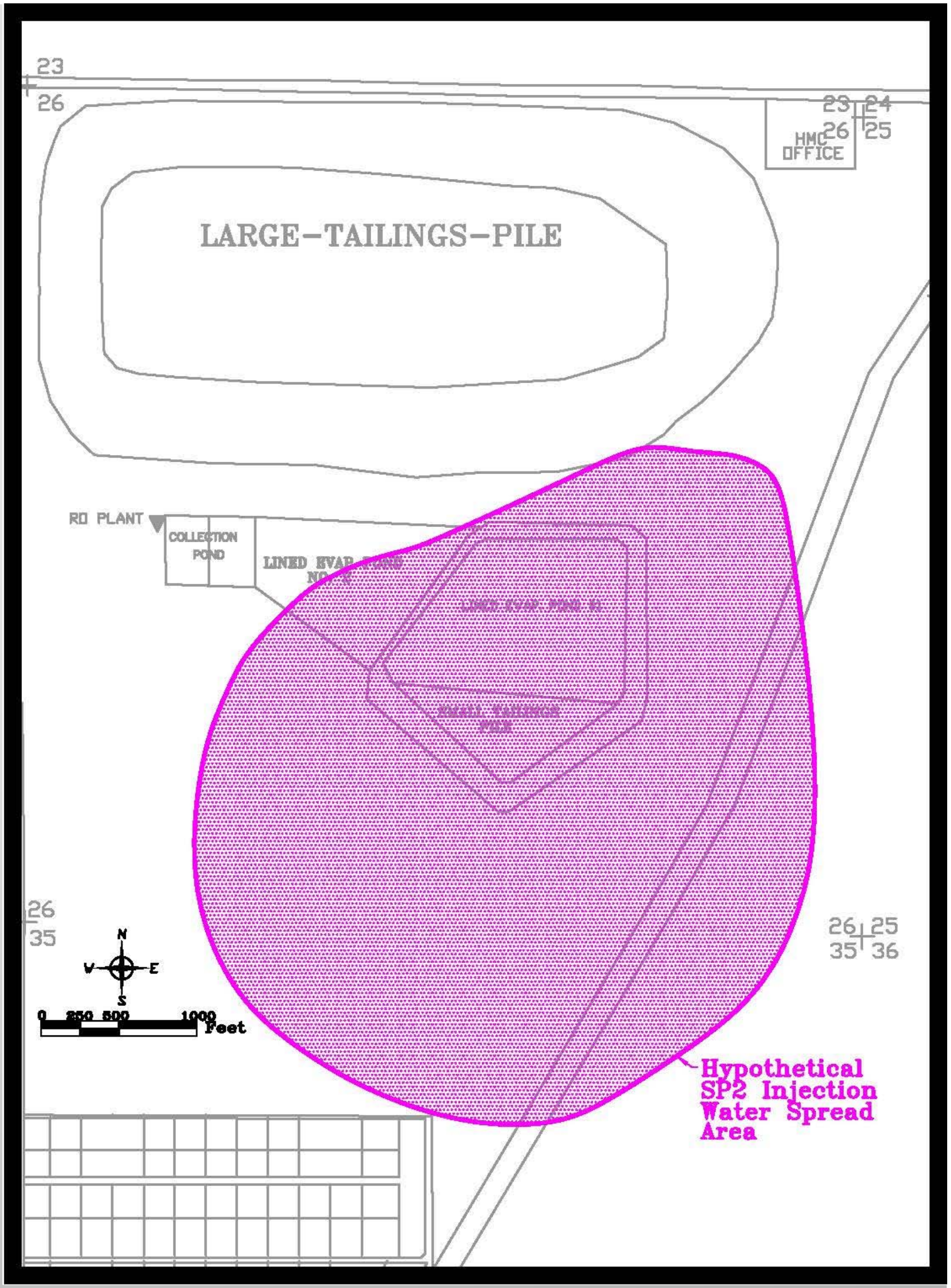
- During the Feb. 2003 thru Jan. 2004 SP2 exceedance event, an estimated 54 kg of molybdenum in excess of the GWPS likely was injected to the ground water
- During the Nov. 2004 SP2 exceedance event, an estimated 36 kg of molybdenum in excess of the GWPS likely was injected to the ground water
- During the Nov. 2004 SP2 exceedance event, an estimated 12 kg of uranium in excess of the GWPS likely was injected to the ground water

Contrast in Injection and Residual/Removed COC Mass

- The excess molybdenum injection masses of 54 kg (2/2003 thru 1/2004) and 36 kg (11/2004) are very small in comparison to the mass in ground water and the mass that was removed by collection
- During 2003, over 10,400 kg of molybdenum was removed from the ground water in the control area and approximately 11,600 kg was removed from the tailings and toe drains
- The excess uranium injection mass of 12 kg in Nov. 2004 is very small in comparison to the mass in the ground water and the mass that was removed by collection
- The average monthly uranium removal from ground water during 2004 was slightly over 550 kg with approximately 600 kg of additional removal through tailings dewatering and toe drain discharge

Hypothetical SP2 Spread Area

- The excess molybdenum and uranium injected during an exceedance would spread and mix with resident ground water
- The spread area shown extends to the edge of the Broadview Acres subdivision
- There is an estimated 354,291,100 gallons of alluvial ground water in the spread area



Estimated Impacts

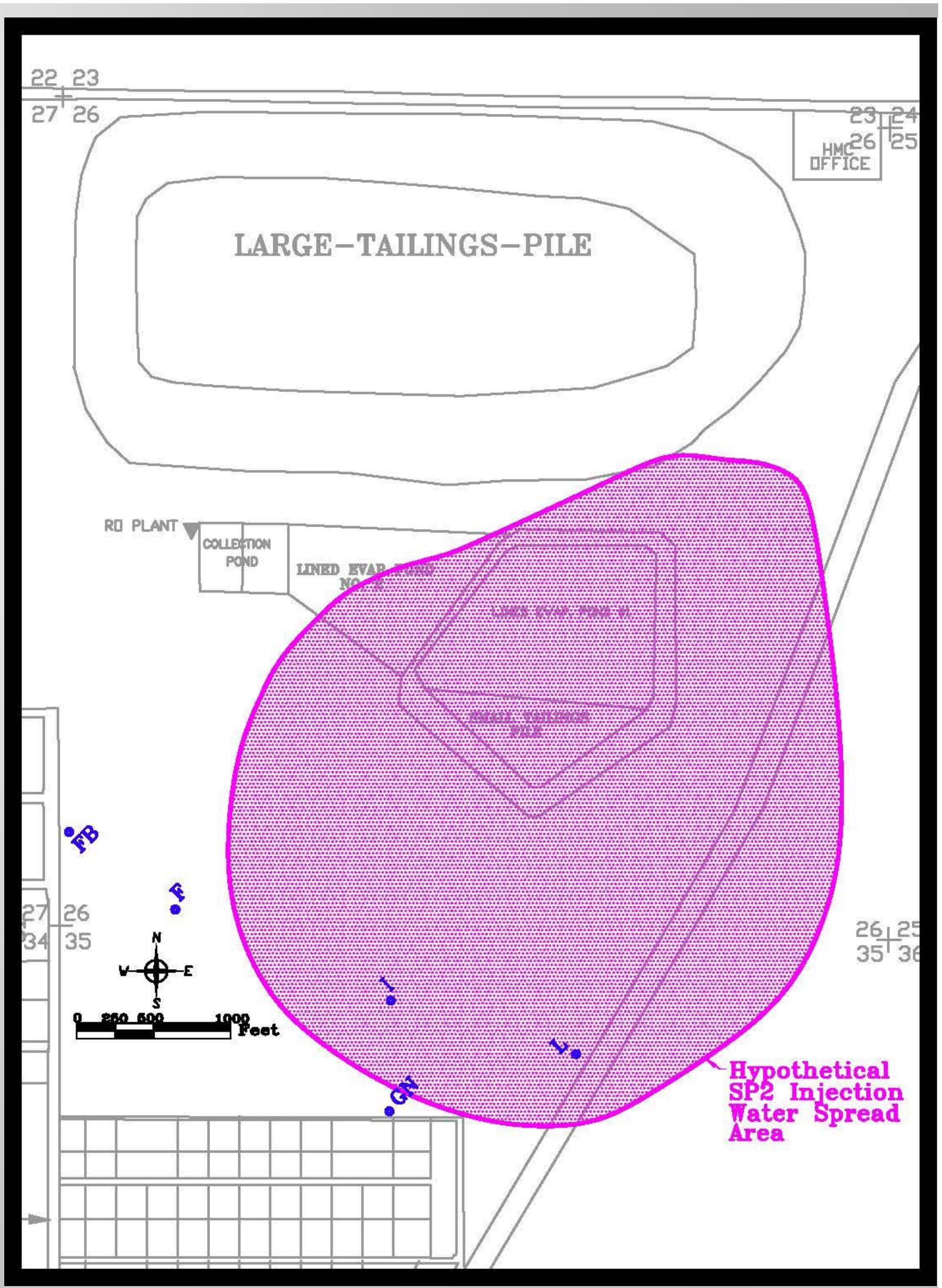
- Using the estimated 54 kg of excess molybdenum injected from Feb. 2003 thru Jan. 2004, the concentration in the hypothetical spread area would increase by 0.04 mg/l
- The preceding calculation is very conservative because it does not consider the mitigating factors
- Using the estimated 36 kg of excess molybdenum injected in Nov. 2004, the concentration in the hypothetical spread area would increase by 0.027 mg/l
- The resident molybdenum concentration in the alluvium as represented by well I was typically 0.015 mg/l (one-half of detection at 0.03 mg/l)
- The sum of the increase due to SP2 injection and resident molybdenum concentration would not exceed the GWPS of 0.10 mg/l

Estimated Impacts (continued)

- Using the estimated 12 kg of excess uranium injected in Nov. 2004, the concentration in the hypothetical spread area would increase by 0.009 mg/l
- The resident uranium concentration in the alluvium as represented by well I in 2004 was 0.0637mg/l
- The sum of the increase due to SP2 injection and resident uranium concentration would not exceed the GWPS of 0.16 mg/l

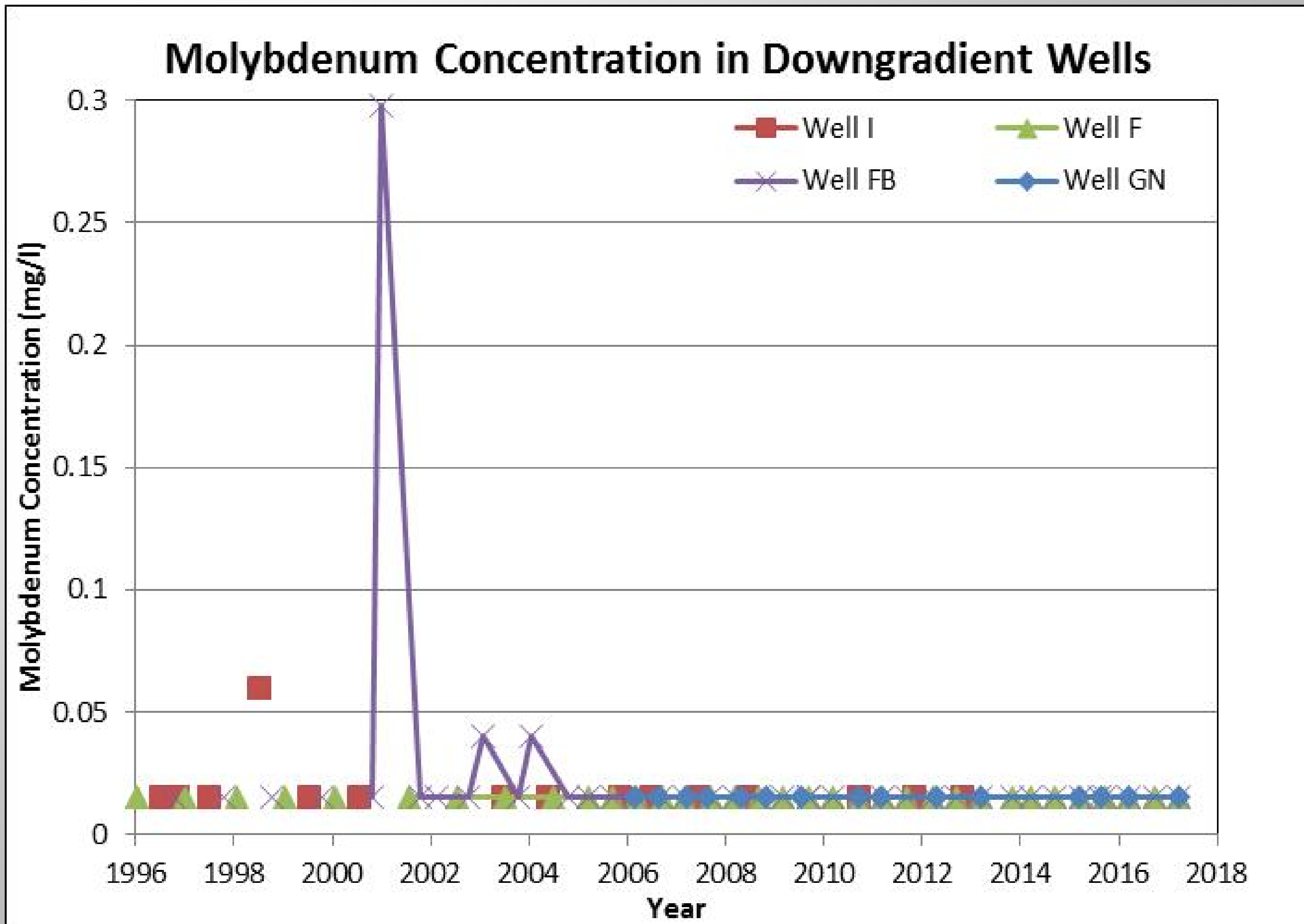
Monitoring Results

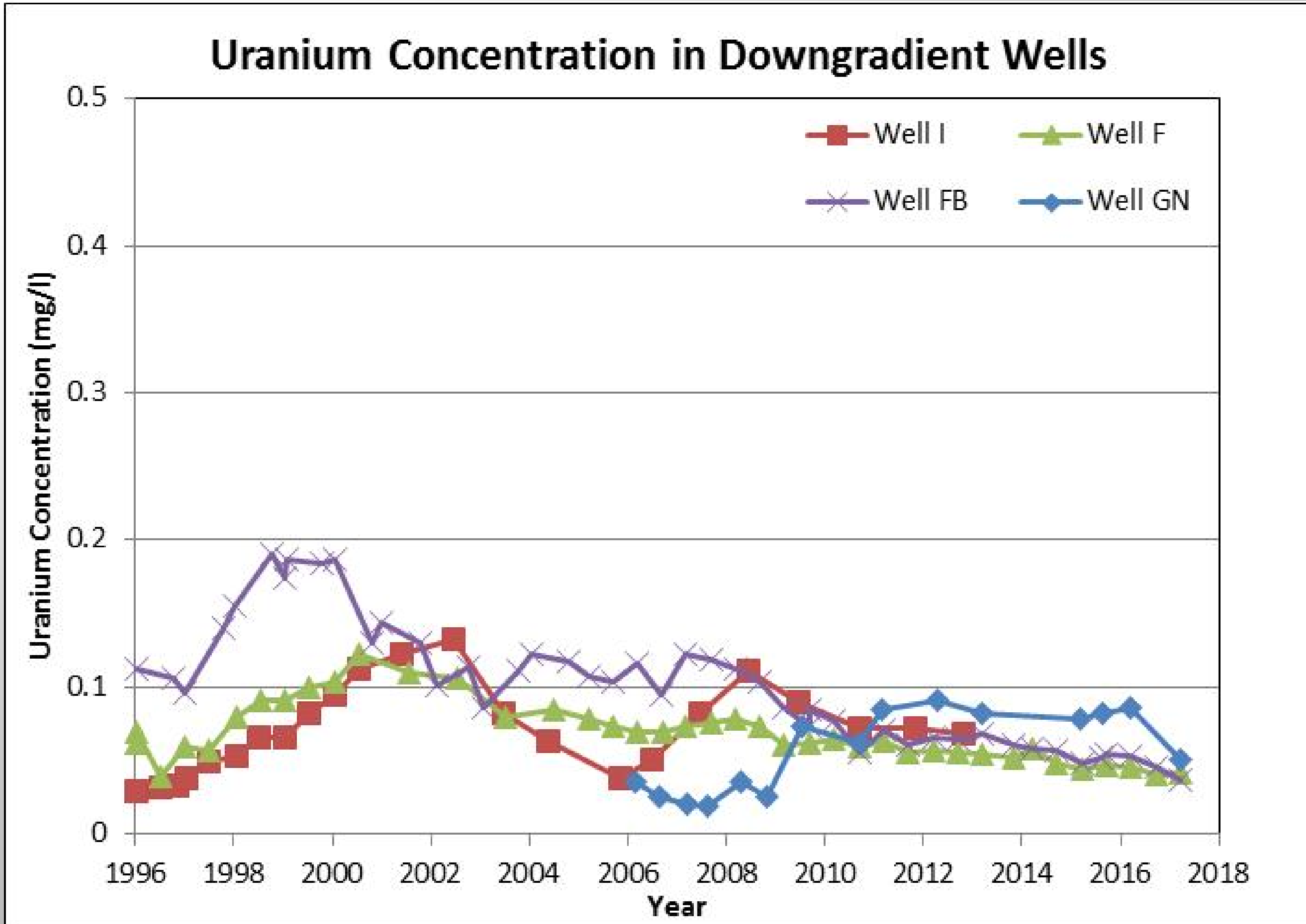
- Some water quality data are available for wells between the SP2 injection area and nearby subdivisions
- Water quality in wells I, F, FB and GN meets GWPSs
- The area near well L was impacted by seepage prior to the SP2 exceedances

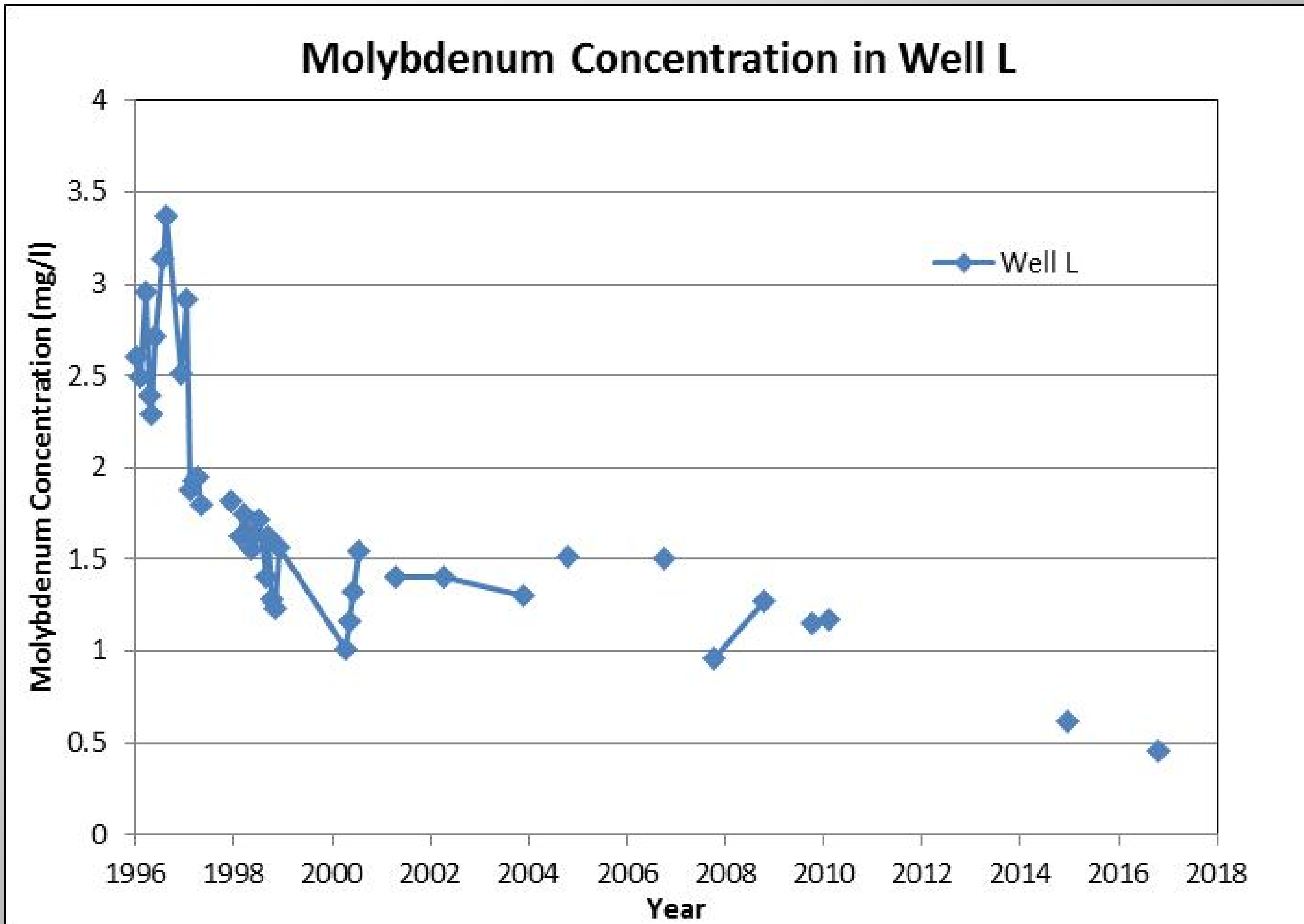


Monitoring Results

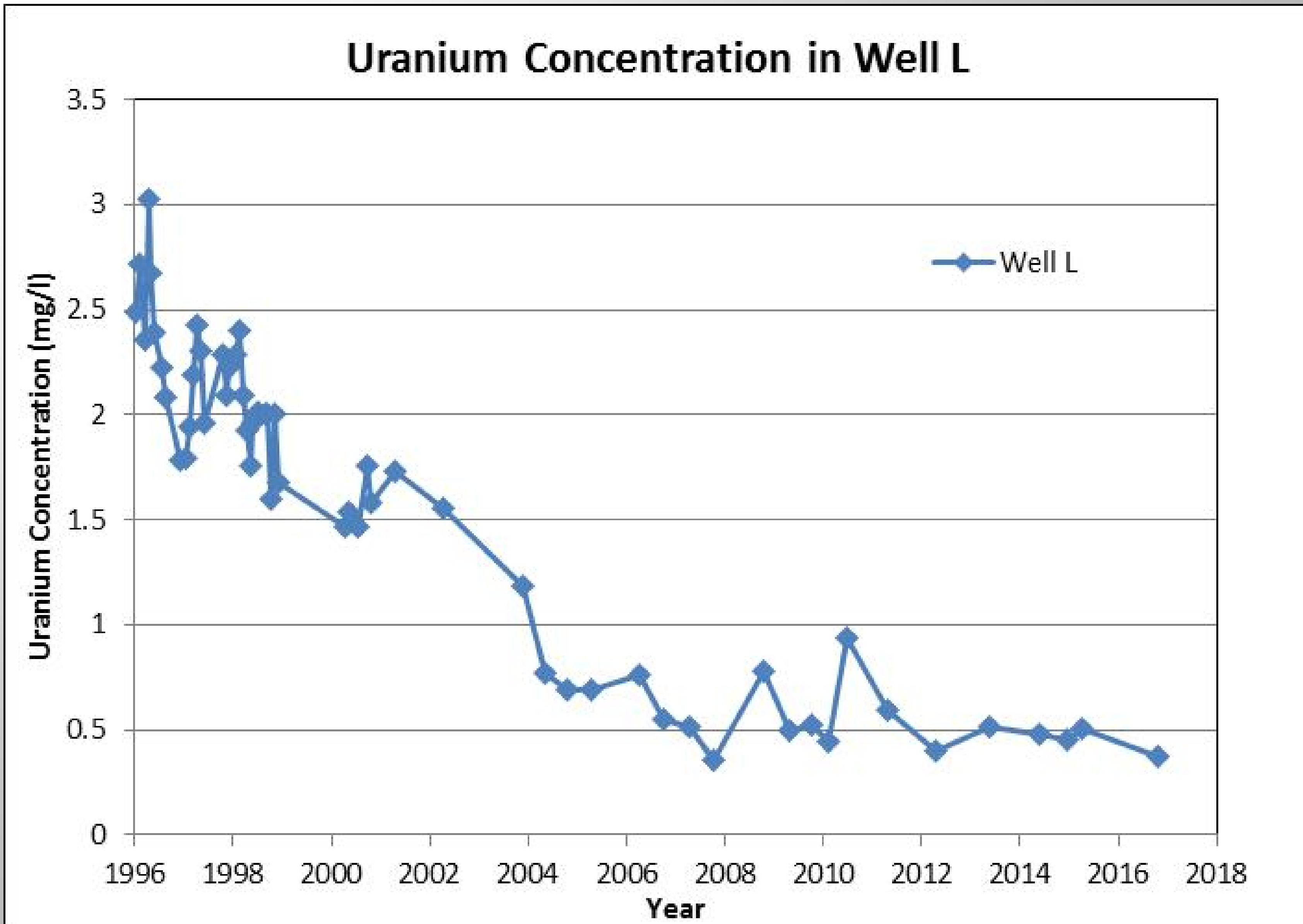
- The following graphs displaying molybdenum and uranium concentration data for wells I, F, FB and GN indicate no impacts attributable to exceedances of GWPSs at SP2
- The following graphs displaying molybdenum and uranium concentration data for well L indicate that the area was impacted prior to the exceedances but significant restoration progress has occurred as a result of collection and injection


Molybdenum Concentration in Downgradient Wells
Well I
Well F
Well FB
Well GN
Molybdenum Concentration (mg/l)
0
0.05
0.1
0.15
0.2
0.25
0.3
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
Year


Uranium Concentration in Downgradient Wells
Well I
Well F
Well FB
Well GN
Uranium Concentration (mg/l)
0.5
0.4
0.3
0.2
0.1
0
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
Year



Molybdenum Concentration in Well L
Molybdenum Concentration (mg/l)
4
3.5
3
2.5
2
1.5
1
0.5
0
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
Year
Well L


Uranium Concentration in Well L
Uranium Concentration (mg/l)
3.5
3
2.5
2
1.5
1
0.5
0
Well L
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
Year

Summary and Conclusions

- The mitigating factors of injection of fresh water outside of the SP2 injection and potential capture by L area collection would have limited or prevented impacts by SP2 exceedances
- Even with a conservative estimate of impacts, any increase in COC concentrations attributable to the SP2 exceedances would have been relatively minor
- The water quality monitoring data in downgradient wells does not exhibit any changes attributable to the SP2 exceedances
- As ground water is effectively contained within the control area, there would have been no impact on human health and the environment

END