

Amendment to CLEANUP ACTION PLAN

Landsburg Mine Site MTCA Remediation Project Ravensdale, Washington

Washington State Department of Ecology

Toxics Cleanup Program
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1.0 INTRODUCTION

The Landsburg Mine Site (Site) is a Washington State Model Toxics Control Act (MTCA) listed site, administered by the Washington State Department of Ecology (Ecology). The history of the Site, summary of the remedial investigation (RI), feasibility study (FS), additional environmental investigations completed at the Site, and the remedial actions selected by Ecology are detailed in the Final Cleanup Action Plan (CAP; Ecology 2017a). This document supplements and amends the CAP to detail the remedial actions required at the Site and approved by Ecology in response to detection of 1,4-dioxane in three groundwater monitoring wells located near the north end of the Site (Ecology 2020).

2.0 BACKGROUND

In response to public comments received on the draft CAP, Ecology added the compound 1,4-dioxane to the suite of analytes listed in the Compliance Monitoring Plan (CMP; Ecology 2017b) for testing during protection and confirmation monitoring at the Site. 1,4-Dioxane was the only new compound added to the CMP at that time. All other compounds included in the CMP have been tested for at the Site during the RI and during the interim groundwater monitoring conducted since 2003. There were no detections of mine waste contaminants in the groundwater monitoring wells located near the north end of the Site during the RI or during any of the interim groundwater monitoring events from 1994 to November 2017.

Prior to the start of remedial actions and the associated compliance monitoring required in the CAP, the Landsburg Potentially Liable Parties (PLP) Group elected to add 1,4-dioxane to the list of test analytes included in the interim groundwater monitoring.

As a result, the November 2017 interim groundwater monitoring round included analysis for 1,4-dioxane for the first time. The analytical results for all test analytes during the November 2017 sampling event were consistent with results during the RI and with all previous interim groundwater monitoring events conducted since 2003, except that 1,4-dioxane was detected in monitoring wells LMW-2 and LMW-4 at concentrations of 2.0 micrograms per liter ($\mu\text{g/L}$) and 2.3 $\mu\text{g/L}$, respectively. Because November 2017 was the first time 1,4-dioxane was tested for at the Site, its detection in LMW-2 and LMW-4 did not necessarily indicate a recent change in groundwater conditions or new release of contaminants from the waste area within the former mine. During the November 2017 sampling event, 1,4-dioxane was not detected in any other Site groundwater sentinel or compliance monitoring wells or the portal surface water samples, including monitoring well LMW-10 and the north portal, which are located upgradient of LMW-2 and LMW-4, and the monitoring wells south of the waste disposal area. Figure 1 shows the location of Site groundwater monitoring wells and monitoring well construction details are provided in Table 1. Figure 2 provides a cross-section showing the monitoring well locations and screen intervals.

2.1 Initial Response Actions

In response to the detection of 1,4-dioxane in LMW-2 and LMW-4, the Landsburg PLP Group, in cooperation with and as approved by Ecology, completed the following actions:

- Expedited the installation of the four additional groundwater monitoring wells referred to as “sentinel wells” in Section 5.5.4 of the CAP (Ecology 2017a). The new sentinel wells included wells: LMW-12, LMW-13R, LMW-14, and LMW-15, which are shown on Figures 1 and 2. Sentinel wells are groundwater monitoring wells that are located between the waste disposal area and the compliance wells at the north and south ends of the Site. The northern sentinel wells, LMW-12 and LMW-13R were installed in March through May 2018. The southern sentinel wells, LMW-14 and LMW-15 were installed in April 2019 and October 2018, respectively.

- Increased the interim monitoring frequency to quarterly for the groundwater monitoring wells located at the north end of the Site. The increased monitoring frequency started in May 2018 and provided additional data to evaluate 1,4-dioxane concentration trends and to confirm that no other compounds were being detected above applicable action levels.
- Installed three additional groundwater monitoring wells (LMW-20, LMW-21, and LMW-22) north of the Site to provide empirical data on the groundwater quality downgradient of the Site and to determine if detectable concentrations of 1,4-dioxane extended towards the Cedar River or nearby private wells. The locations of these three wells were selected in consultation with Ecology.

These initial response actions to further address 1,4-dioxane were in addition to CAP requirements and did not delay implementation of the Site-wide remedial actions specified in the CAP (Ecology 2017a).

2.2 1,4-Dioxane Alternative Source Evaluation Report

Based on Landsburg PLP Group's consultation with Ecology, and as provided in the CAP, the results of the investigations described above were presented to Ecology in the report "*1,4-Dioxane Alternative Source Evaluation*" (Golder 2019). This report concluded: "The low-level detections of 1,4-dioxane in three Site monitoring wells (LMW-2, LMW-4, LMW-12) downgradient of the waste disposal area, indicates that the 1,4-dioxane could possibly be a mine waste contaminant. However, the absence of 1,4-dioxane in LMW-13R, which is downgradient of the waste disposal area and is screened at a depth that is shallower than LMW-4 does not support this determination." The report's assessment of the 1,4-dioxane detection indicated the following:

- Quarterly groundwater monitoring since the initial detection of 1,4-dioxane indicated that the concentrations of 1,4-dioxane decreased following the initial detections and were remaining steady.
- Analyses of groundwater samples collected during quarterly monitoring did not detect any other contaminants that would indicate mine waste contaminants were migrating from the mine.
- 1,4-Dioxane was not detected in groundwater samples from the three new groundwater monitoring wells (LMW-20, LMW-21, LMW-22) installed north of the Site and downgradient of LMW-2 and LMW-4. Groundwater elevation data from these wells confirm that groundwater discharging from the Rogers seam flows towards the Cedar River, and 1,4-dioxane does not reach the Cedar River.
- The horizontal and vertical extent of the 1,4-dioxane have been delineated. There are no current downgradient drinking water receptors located between the Site and the Cedar River, and installation of private groundwater wells within the area where 1,4-dioxane is detected above MTCA cleanup levels is prohibited by the environmental covenants contained within Exhibit E of the CAP (Ecology 2017a). The 1,4-dioxane therefore does not present a threat to human health or the environment.

2.3 White Paper – 1,4-Dioxane Detection, Occurrence, and Evaluation of Remedial Alternatives

Following the Alternative Source Evaluation Report, the PLP Group, with Ecology's concurrence, prepared a White Paper (Golder 2020a) to evaluate the 1,4-dioxane detections at the Site, summarize actions completed to evaluate the 1,4-dioxane detections, and present Ecology with an evaluation of remedial alternatives to determine protective and appropriate remedial action(s) to address the 1,4-dioxane detected at the Site. Key conclusions from the White Paper are summarized below.

During the period from 2018 to 2020, the reported concentrations of 1,4-dioxane detected at the site were consistently below 2.0 µg/L. The concentration trends in LMW-2 and LMW-4 were steady and decreasing concentration trends were noted in sentinel well LMW-12. Table 2 presents the 1,4-dioxane results reported during quarterly sampling events.

There are currently no drinking water levels established by EPA or in Washington State for 1,4-dioxane. The World Health Organization suggests a 50 µg/L drinking water threshold for 1,4-dioxane, whereas the EPA National Center for Environmental Assessment proposed a health-based advisory level of 3 µg/L in tap water (Water Research Foundation 2014). Under MTCA, Ecology has set a groundwater cleanup level for 1,4-dioxane of 0.44 µg/L. This value assumes that a person is drinking 2 liters of the impacted water every day for 30 years, which could result in an excess cancer risk of less than one in one million. A MTCA Method B surface water value, calculated using a bioconcentration factor of 0.5 liters per kilogram (Oak Ridge National Laboratory's Risk Assessment Information System [RAIS 2018]) and the oral cancer potency factor listed in Cleanup Levels and Risk Calculation (CLARC) of 0.1 kilograms per day per milligram (kg-day/mg), results in a MTCA Method B surface water value of 130 µg/L.

The White Paper evaluated current and potential future exposure pathways and concluded that the low-level detection of 1,4-dioxane in LMW-2, LMW-4, and LMW-12 does not present a current or likely future risk to human health or the environment.

Various 1,4-dioxane treatment technologies and remedial alternatives were evaluated in the White Paper. Included in this analysis was an assessment of the potential implementation of the contingent groundwater extraction and treatment system specified in the CAP. The purpose of the contingent treatment system described in the CAP was to address the scenario where contaminants started being detected coming out of the mine at concentrations exceeding trigger levels. The evaluation conducted in the White Paper assessed whether the contingent groundwater extraction system should be used to address the current condition where low-levels of 1,4-dioxane were detected in LMW-2, LMW-4, and LMW-12. The evaluation concluded that implementation of the contingent groundwater extraction and treatment system under the existing conditions would have significant sustainability impacts and disproportionately high financial costs, with minimal to no reduction in risk, based on the low levels and limited extent of the 1,4-dioxane present at the Site. The White Paper identified alternative remedial actions that were more appropriate to address the low level 1,4-dioxane detected at the Site and ensure the long-term protection of human health and the environment. These alternative remedial actions are described in the following sections of this CAP Amendment.

3.0 CLEANUP ACTION PLAN AMENDMENTS

Ecology reviewed the data collected from the Site and the evaluations presented in the White Paper and issued a final decision letter (Ecology 2020) concurring with the alternate remedial action described in the White Paper with additional requirements. The alternate remedial actions agreed upon by Ecology supplement and amend the CAP, including the contingent response actions in Section 5.5.5.5, to address the low level 1,4-dioxane groundwater detections at the north end of the Site.

The remedial actions required by Ecology to ensure that human health and the environment continue to be protected at the Site regarding 1,4-dioxane are:

- Continue to implement capping the portions of the trench required in the CAP but upgrade the cover from a low-permeability soil cover to a geomembrane cover system. The upgrade will nominally achieve a permeability of 1×10^{-11} centimeters per second (cm/sec) or less, which is 10,000 times less permeable than

the low-permeability soil layer prescribed in the CAP. This will significantly reduce the percolation of rainwater through the former waste disposal area, and if the 1,4-dioxane is a mine waste contaminant, will further reduce the flux of 1,4-dioxane to groundwater.

- Continue the increased groundwater monitoring frequency of the north end wells to provide a high level of confidence that concentrations of 1,4-dioxane continue to remain steady or attenuate.
- Add routine monitoring of the three new off-Site groundwater monitoring wells located north of the Site to confirm that 1,4-dioxane attenuates within a short distance north of the Site.
- Complete the extension of the Contingency Plan discharge line from the north contingent treatment pad to connect to the nearest municipal sewer line, the Soos Creek sewer line located west of the Site. Having this line installed and ready for discharge will increase the ability to respond rapidly if conditions change at the Site and implementation of the Contingency Plan were triggered.

Ecology's decision letter also required the following:

- "Except for the documented 1,4-dioxane exceedances at the northern portal wells, the trigger levels and contingent actions pursuant to the Contingent Groundwater Extraction and Treatment System Plan (Exhibit D, Part C of the CAP) shall be strictly enforced for all other contaminants of concern in this area of the Site and will be strictly enforced for all contaminants of concern (including 1,4-dioxane) at the rest of the Site. Should a surge of 1,4-dioxane be detected coming from the interior of the former mine above the concentration levels and locations described in the White Paper and the August 16, 2020 Technical memorandum titled "Pre-Remedial Action 1,4-Dioxane Detection at the Landsburg Mine Site", the contingent groundwater extraction and treatment system shall be implemented in strict accordance with the cleanup plan."
- *In Situ* Bioremediation (ISB), including bioaugmentation and cometabolic bioremediation, should be evaluated and implemented if feasible for the northern site wells in which the 1,4-dioxane was detected. The work shall be performed by a professional environmental microbiologist or remediation expert who specializes in bioremediation technologies. The scope of work may include microcosm, bench scale, and pilot studies to determine if this approach would effectively remediate the 1,4-dioxane exceedances at the site.
- Complete a systematic inventory and evaluation of the full analytical suite of chemicals listed in the CMP (Ecology 2017b) for groundwater monitoring at the site to confirm that there are no other chemicals with concentrations at or above the trigger levels of the CAP. As this assessment is not directly related to the 1,4-dioxane detections, Ecology is completing this evaluation separate from the CAP Amendment considerations presented herein.

4.0 ACTIVITIES AND SCHEDULE TO COMPLETE FINAL CAP AND 1,4-DIOXANE REMEDIAL ACTIONS

The following activities have been completed or will be completed in compliance with the Final CAP and the additional 1,4-dioxane remedial actions required by Ecology.

4.1 Geomembrane Cover System

The Landsburg PLP Group submitted engineering design drawings and specifications for installation of the geomembrane cover system to Ecology (Golder 2020b), which were subsequently reviewed and approved by Ecology. Construction of the cover system was completed during the period of September to November 2020 and included the following activities:

- **Regrading.** The existing ground surface above and adjacent to the backfilled trenches was regraded to the lines and grades shown on the design drawings to provide proper stormwater drainage away from the backfilled trenches.
- **Cover Construction.** A multi-layer permanent closure cover was constructed above the backfilled trenches. The cover layers, from bottom to top above the regraded surface, included the following:
 - A 60-mil linear low density polyethylene (LLDPE) geomembrane, textured on both sides, to serve as a barrier to infiltration of precipitation water, with heat-sealed and pressure-tested seams to confirm integrity throughout the installation area.
 - A geocomposite drainage layer consisting of a high density polyethylene (HDPE) geonet, with non-woven polypropylene geotextiles thermally bonded to both sides, to serve as a drainage layer that prevents hydrostatic head buildup on the geomembrane and provided physical protection during placement of the overlying soil layer.
 - A 1.5-foot-thick general fill soil layer above the geocomposite layer to provide physical protection to the geosynthetic layers.
 - A 0.5-foot-thick vegetative soil layer over the general fill soil to support vegetation growth.
 - A hydroseeded vegetative cover consisting of a grass mixture to minimize erosion and enhance evapotranspiration during the growing season.

In conjunction with the cover system, and as provided in the CAP, the Landsburg PLP Group also constructed a surface water management system to control stormwater on the Site. The installation of this system was completed in November 2020, and includes the following:

- Grass-lined drainage ditches in flatter areas (slopes less than 6%) adjacent to the closure cover and access roads.
- Rock-lined drainage ditches in steeper areas adjacent to the closure cover and access roads.
- 18-inch-diameter corrugated metal pipe culverts to convey stormwater from drainage ditches under Site access roads.
- A downslope conveyance subsystem from the cover area to an infiltration pond at lower elevation. The components of this subsystem include:
 - A precast concrete drop structure at the top of the slope, with an armor rock entrance channel
 - A 12-inch-diameter HDPE pipe running down the slope on the ground surface, anchored at regular intervals

- A 16-inch-diameter HDPE pipe sleeve connecting the 12-inch-diameter HDPE pipe to a precast concrete energy dissipator
- A precast concrete energy dissipator at the bottom of the slope
- A buried 12-inch-diameter HDPE pipe from the energy dissipator to the infiltration pond
- A 12,000-square-foot infiltration pond excavated 4 to 5 feet below existing grade in the flat area adjacent to Summit Landsburg Road. The pond includes a central divider berm to allow sediment to settle in the inlet side and an outlet swale for overflow only during extreme precipitation events.

4.2 Increased Groundwater Monitoring Frequency

Since the initial detection of 1,4-dioxane in November 2017, the groundwater monitoring wells located at the north end of the Site (LMW-2, LMW-4, LMW-10, LMW-12, and LMW-13R [“north end wells”]) have been sampled on a quarterly monitoring frequency. The increased monitoring frequency provided additional data to evaluate 1,4-dioxane concentration trends and to confirm that no other compounds were being detected above applicable action levels. Table 2 presents the results of the quarterly groundwater monitor for 1,4-dioxane, and Figure 3 shows the 1,4-dioxane trends for the three wells (LMW-2, LMW-4, and LMW-12) where 1,4-dioxane has been detected. 1,4-Dioxane has not been detected in any other Site groundwater monitoring wells or in the additional monitoring wells installed north of the Site (LMW-20, LMW-21, and LMW-22). The 1,4-dioxane concentration trends in LMW-2 and LMW-4 have been steady and decreasing concentration trends are noted in sentinel well LMW-12.

As required in Ecology’s Final Decision letter, increased groundwater monitoring frequency of the north end wells will continue until at least five years of quarterly groundwater data have been collected. Five years of quarterly monitoring data will provide 20 discrete sampling data points in each of the north end monitoring wells, which is a statistically significant number of data points to evaluate concentration trends. Following procedures detailed in the US Environmental Protection Agency (EPA) document *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance* (Unified Guidance) (EPA 2009), statistical trend analyses will be conducted on the data. Procedures for applying different statistical methods (e.g., linear regression, Mann-Kendall trend test, and Theil-Sen trend line) to evaluate concentration trends is contained in Chapter 17.3 of the Unified Guidance. The statistical trend method(s) most suitable to the distribution of the Landsburg data will be used to evaluate concentration trends. Statistical trend analysis will be conducted on the data collected during the five years of quarterly groundwater monitoring. If the statistical calculations confirm that the concentrations of 1,4-dioxane detected in LMW-2, LMW-4, and LMW-12 are steady to decreasing, the groundwater monitoring program will continue in accordance with the CMP (Ecology 2017b). If trend analysis indicates increasing concentration trends quarterly monitoring will continue.

4.3 Monitoring Three Off-Site Groundwater Monitoring Wells Located North of the Site

To provide empirical data on the groundwater quality to the north, between the Site and the Cedar River, three additional groundwater monitoring wells were installed from November 27 to 29, 2018. Details on the installation and testing of these wells are provided in the Alternative Source Evaluation Report (Golder 2019) and in the White Paper (Golder 2020a). Groundwater sampling and analysis of these three wells indicated no volatile organic compound (VOC) analytes or 1,4-dioxane were detected above the reporting limits. Collection of groundwater monitoring data from these wells will be continued to confirm that 1,4-dioxane attenuates within a short distance north of the Site.

The locations of monitoring wells LMW-20, LMW-21, and LMW-22 are shown on Figure 2. Groundwater monitoring will be conducted at these three wells following the groundwater monitoring procedures described in the CMP (Ecology 2017b). Starting in 2021, all three wells will be sampled semi-annually and analyzed for 1,4-dioxane. Semi-annual sampling of LMW-20, LMW-21, and LMW-22 will continue for the duration of the increased monitoring frequency described in Section 4.2 for the groundwater monitoring wells located on the north end of the Site. If the statistical analysis performed on the data collected from the north end Site wells indicates that the concentrations of 1,4-dioxane are steady to decreasing, monitoring of LMW-20, LMW-21 and LMW-22 will be discontinued. Steady to decreasing trends in wells located on Site would confirm that no impacts to off-Site, downgradient wells will occur.

4.4 Complete the Extension of the Contingency Plan Discharge Pipe

Pursuant to the CAP, components of the Contingent Groundwater Extraction and Treatment System that have long construction times have already been installed, apart from completing the extension of the 3-inch-diameter discharge line and connecting it to the Soos Creek sewer line located west of the Site. Various permits and access agreements will be required to extend the buried discharge pipe across King County park land, along the right-of-way of Summit-Landsburg Road, and connect it to the Soos Creek sewer line. Ms. Karen Wolf, Senior Executive Policy Advisor for King County (King County 2006) provided preliminary agreement for completing these activities to Ecology during the early planning stages of the CAP. Having this line installed and ready for discharge to the Soos Creek sewer line for treatment at the King County South Plant treatment system would increase the ability to respond rapidly if conditions change and groundwater impacts observed at the Site trigger implementation of the Contingency Plan.

Draft design drawings and specifications for extending the existing 3-inch-diameter discharge line and connecting the line to the Soos Creek sewer line will be submitted to Ecology within 60 days of the Court's approval of this Amendment to the CAP. Ecology will provide comments on the draft design drawings and specifications. Final design drawings and specifications will be submitted to Ecology within 30 days following receipt of Ecology's comments. Installation of the discharge line extension and connection to the Soos Creek sewer line should be completed within six months of Ecology's approval of the final design drawings and specifications.

4.5 Evaluation of *In Situ* Bioremediation Option

In situ bioremediation is an emerging treatment technology that has been documented in pilot studies and consists of the addition of chemicals to induce aerobic groundwater conditions and injection of bacterial culture to induce metabolic biodegradation of 1,4-dioxane. The injection of additional chemical substrates (e.g., butane, propane, ethane) are required to induce cometabolic biodegradation of 1,4-dioxane (Chiang et al. 2016). A 1,4-dioxane *in situ* bioremediation evaluation will be submitted to Ecology to determine if this approach could safely and effectively remediate the 1,4-dioxane exceedances at the Site, without degrading groundwater quality. The evaluation, to be carried out by a professional environmental microbiologist or bioremediation specialist will analyze the feasibility, effectiveness, and potential environmental impacts associated with implementing *in situ* bioremediation at the Site versus other remedies and will consider whether any additional testing may be necessary to support that evaluation. The evaluation will include a schedule if additional testing is identified as necessary. This evaluation will be submitted to Ecology for approval within 60 days of the Court's approval of this Amendment to the CAP, and if additional testing is required, that will occur in accordance with the included schedule.

If the evaluation approved by Ecology indicates *in situ* bioremediation is appropriate for the Site, the PLPs will provide a plan to implement bioremediation within 120 days after approval of the evaluation. After Ecology approval, the plan will be conducted by PLPs in accordance with the included schedule.

4.6 Contingent Groundwater Treatment System Triggers for 1,4-Dioxane in the North End Wells

Statistically significant increasing trends of 1,4-dioxane in any of the north end wells (LMW-2, LMW-4, LMW-10, LMW-12, and LMW-13R) that indicate increasing concentrations of 1,4-dioxane are coming from the interior of the former mine will require implementing the contingent groundwater extraction and treatment system plan, described in CAP, Exhibit D, Part C (Ecology 2017a). For the purpose of this requirement, statistically increasing 1,4-dioxane concentration trends (Unified Guidance, EPA 2009) and a confirmed concentration exceeding 20 µg/L would indicate an increase in the potential risks that were evaluated in the White Paper and would trigger implementation of the contingent groundwater extraction and treatment system plan. In accordance with Section 5.0 below, if 1,4-dioxane is detected in any Site wells, other than the north end wells, the trigger levels and contingent actions pursuant to the Contingent Groundwater Extraction and Treatment System Plan (Exhibit D, Part C of the CAP) shall be strictly enforced.

5.0 LIMITATIONS

This Amendment to the CAP pertains only to the documented 1,4-dioxane exceedances detected in the north end of the Site wells. Except as specifically provided in this Amendment, all other provisions and requirements contained within the approved CAP (Ecology 2017a) and all associated Exhibits to the Decree and CAP remain unchanged.

6.0 REFERENCES

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Tables

Table 1: Landsburg Mine Site Groundwater Monitoring Wells Construction Summary

Well ID	Northing	Easting	Installation Date	Date Last Surveyed	Datum	Measuring Point Elevation (ft NAVD88)	Measuring Point	Borehole Depth (ft bgs)	Borehole Diameter (inches)	Well Casing Diameter (inches)	Well Materials	Depth to Top of Screen (ft bgs)	Depth to Bottom of Screen (ft bgs)	Elevation Top of Screen (ft NAVD88)	Elevation Bottom of Screen (ft NAVD88)	Screen Slot Size (inches)	Depth to Top of Filter Pack (ft bgs)	Comments
LMW-1	138279.52	1354991.57	1/23/1994	8/14/2018	NAVD88	765.36	Top of PVC Casing	180	8	4	Stainless/PVC	162	177	603	588	0.02	158	In area of gangway that connects mine fault off-set
LMW-2	139077.61	1355972.91	2/11/1994	8/14/2018	NAVD88	617.79	Top of PVC Casing	46	8	4	Stainless/PVC	28	38	590	580	0.02	25	Shallow north compliance
LMW-3	135192.23	1353220.37	11/22/2004	11/3/2004	NAVD88	656.75	Top of PVC Casing	76	8	4	Stainless/PVC	50	65	607	592	0.02	47	Shallow south compliance
LMW-4*	139122.67	1355865.52	2/19/1994	8/14/2018	NAVD88	619.27	Top of PVC Casing	233	8	4	Stainless/PVC	195	210	424	410	0.02	210	Deep north compliance
LMW-5	135206.05	1353141.36	12/8/2004	11/3/2004	NAVD88	658.27	Top of PVC Casing	247	8	4	Stainless/PVC	232	242	426	416	0.02	232	Deep south compliance
LMW-6	138714.14	1354126.78	1/13/1994	11/3/2004	NAVD88	632.33	Top of PVC Casing	106	8	4	Stainless/PVC	91	106	541	526	0.02	83	Frasier Coal Seam
LMW-7*	138055.10	1355483.61	1/10/1994	11/3/2004	NAVD88	771.51	Top of PVC Casing	254	8	4	Stainless/PVC	240	254	532	518	0.02	n/a	Landsburg Coal Seam
LMW-8	135074.90	1353229.41	4/7/2004	11/3/2004	NAVD88	646.97	Top of PVC Casing	15	9	2	PVC	7.5	13	639	634	0.02	6	Representative of Portal #3 discharge
LMW-9	135727.33	1353324.04	4/14/2004	11/3/2004	NAVD88	743.99	Top of PVC Casing	160	9	2	PVC	149	159	595	585	0.02	144	Southern Sentinel Well mid-depth
LMW-10	139054.56	1355787.97	5/11/2004	8/14/2018	NAVD88	618.98	Top of PVC Casing	450	9	4	PVC	267	287	352	332	0.02	258	Deep, near bottom of mine, northern end
LMW-11	136159.27	1353317.36	8/24/2005	4/19/2019	NAVD88	802.19	Top of PVC Casing	707	9	4	Stainless/PVC	697	707	105	95	0.02	688	Deep, near bottom of mine, south end
LMW-12	138923.92	1355721.80	3/14/2018	8/14/2018	NAVD88	625.35	Top of PVC Casing	30	8	4	PVC	15.5	25.5	610	600	0.02	11	North Portal Sentinel Shallow Sentinel Well
LMW-13R	138932.43	1355728.92	5/15/2018	8/14/2018	NAVD88	625.86	Top of PVC Casing	151	8	4	PVC	115	140	511	486	0.02	110	North Portal Sentinel Deep Sentinel Well
LMW-14*	137188.61	1353967.91	4/15/2019	4/19/2019	NAVD88	805.12	Top of PVC Casing	176	6	2	PVC	156.5	172.3	649	633	0.01	152.6	15° Incline. Vertical depths reported
LMW-15	136245.07	1353517.07	11/5/2018	4/19/2019	NAVD88	796.46	Top of PVC Casing	248	6	2	PVC	238	248	558	548	0.01	233	South cap effectiveness well
LMW-20	139352.05	1356317.06	11/27/2018	12/26/2018	NAVD88	546.80	Top of PVC Casing	24.5	6	2	PVC	14	24	533	523	0.01	11	Cedar River Valley Rogers Seam
LMW-21	139209.99	1356404.12	11/29/2018	12/26/2018	NAVD88	544.09	Top of PVC Casing	15	6	2	PVC	10	15	534	529	0.01	7	Cedar River Valley East Well
LMW-22	139493.44	1355909.73	11/28/2018	12/26/2018	NAVD88	542.86	Top of PVC Casing	27.5	6	2	PVC	17	27	526	516	0.01	14	Cedar River Valley West Well

Notes:
 * LMW-4 and LMW-7 were drilled at a 20° incline; LMW-14 was drilled at 15° incline.
 ** No filter pack was installed in P-2 due to the open mine shaft at 39 feet to 44 feet. The casing was removed, and the native material collapsed around the well to 15 feet below ground surface.
 ft bgs - feet below ground surface

March 2021

Table 2: Summary of 1,4-Dioxane Detections in Groundwater Monitoring Wells Located on the North End of the Site

Sample Date	LMW-2	LMW-4	LMW-10	LMW-12	LMW-13R
	µg/L	µg/L	µg/L	µg/L	µg/L
11/30/2017	2.0	2.3	0.4 U	NA	NA
2/9/2018	2.1	2.3	NA	NA	NA
5/24/2018	1.8	1.5	0.4 U	1.5	0.4 U
8/15/2018	1.6	1.5	0.4 U	1.6	0.4 U
12/4/2018	1.7	1.6	0.4 U	1.2	0.4 U
3/5/2019	1.5	1.7	0.4 U	1.1	0.4 U
5/22/2019	1.5	2 (1.5)	0.4 U	1.4	0.4 U
8/14/2019	1.8	1.5	0.4 U	1.6	0.4 U
12/10/2019	1.5	1.6 (1.6)	0.4 U	0.4 U	0.4 U
3/10/2020	1.6	1.3 (1.4)	0.4 U	1.0	0.4 U
6/25/2020	1.8 (1.8)	1.8	0.4 U	0.5	0.4 U
9/16/2020	1.6 (1.7)	1.8	0.4 U	0.6	0.4 U

Notes:

U - The analyte was not detected above the laboratory method detection limit of 0.04 µg/L.

µg/L = micrograms per liter

Analyses performed by EPA Method 8270

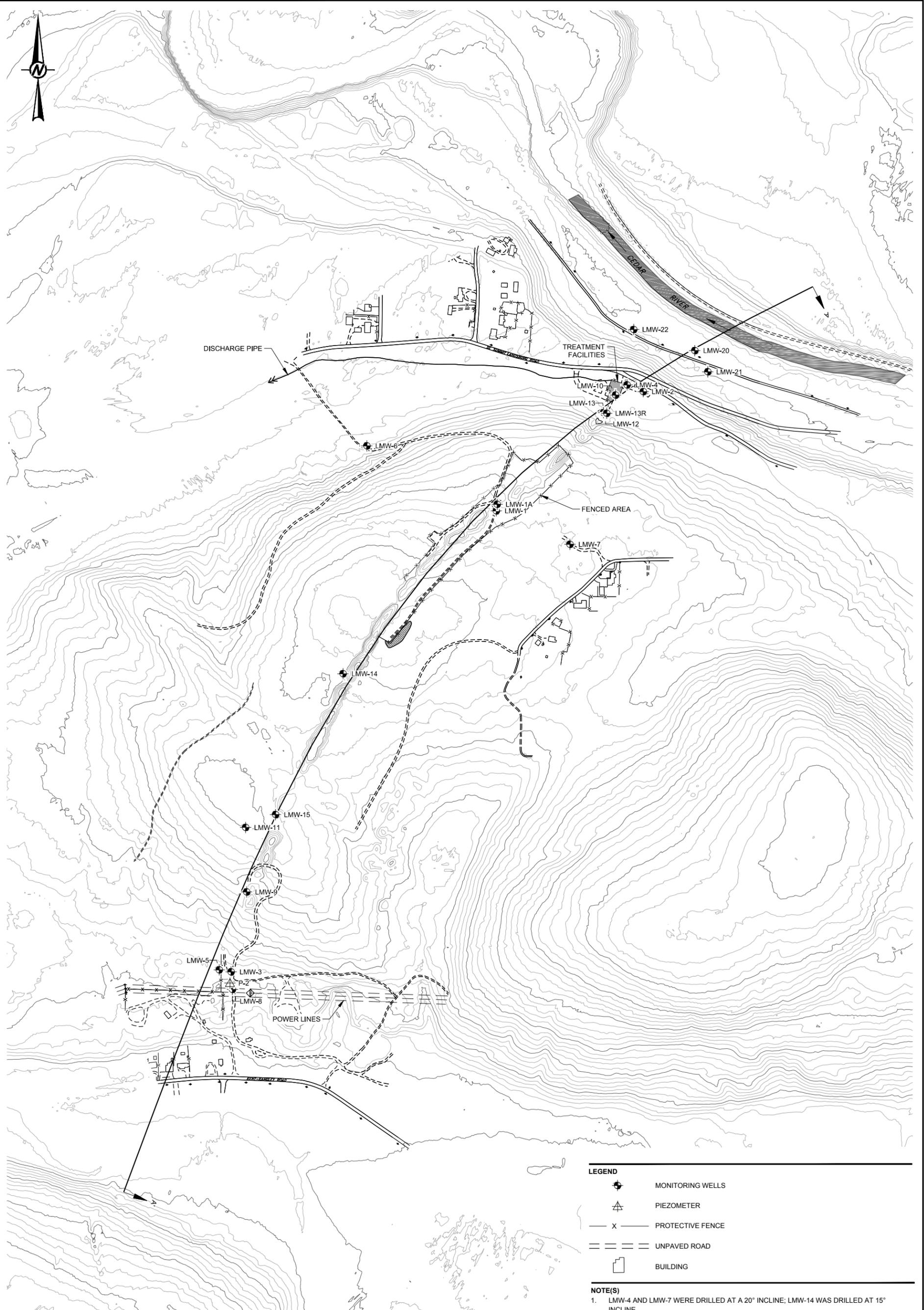
NA = Not Analyzed

Duplicate results are included in parentheses

MTCA Method B Cleanup Level of 1,4-Dioxane is 0.44 µg/L

1,4-dioxane was not detected in any other Site groundwater monitoring wells

Figures



LEGEND

- MONITORING WELLS
- PIEZOMETER
- PROTECTIVE FENCE
- UNPAVED ROAD
- BUILDING

NOTE(S)
 1. LMW-4 AND LMW-7 WERE DRILLED AT A 20° INCLINE; LMW-14 WAS DRILLED AT 15° INCLINE

CLIENT
 LANDSBURG MINE SITE PLP GROUP

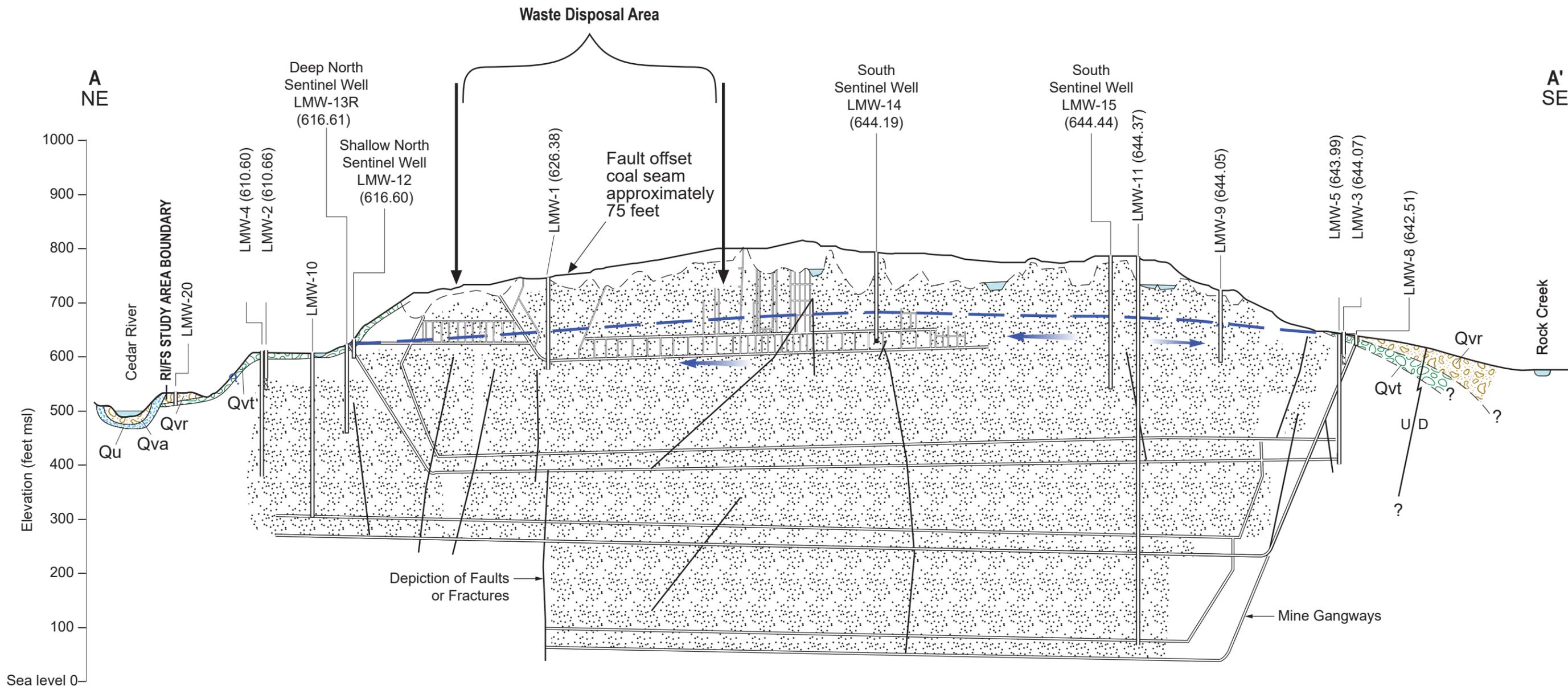
PROJECT
 LANDSBURG MINE SITE
 MTCA REMEDIAL ACTION

CONSULTANT	YYYY-MM-DD	2019-04-25
DESIGNED	XXX	
PREPARED	XXX	
REVIEWED	XXX	
APPROVED	XXX	

TITLE	PROJECT NO.	PHASE	REV.	SHEET
SITE MAP	9231000005	1200	A	1



1 in IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM A NS/D



Sea level 0

EXPLANATION

- Potentiometric surface
- Outline of trench bottom
- Well ID (water level in ft. amsl)
- Qvt Till, compact mixture of gravel occasional boulders in clayey silty sand matrix
- Sandstone
- Surface water feature
- Anticipated collapsed zone within mine
- Qu Drift, till, fluvial sand and gravel, lacustrine sand, silt, clay and peat
- Qvr Recessional outwash, well sorted sand and pebble-cobble
- Qva Advanced outwash pebble-cobble gravel may include very fine sand
- Monitoring Interval



Groundwater Flow Direction

Sources for the Geology and Mine Information:
 J.E. Luzier 1969; surficial geology
 State of Washington, Water Well reports
 Mine Superintendent's Records
 Landsburg Well Logs

NOTE: Vertical to horizontal scale ratio is 2.5:1
 Wells are project normal into the strike of the Cross-Section
 A-A' Groundwater elevation obtained 6/25/2020

CLIENT	LANDSBURG PLP GROUP		PROJECT	LANDSBURG MINE SITE	
CONSULTANT	YYYY-MM-DD	2020-08-17	TITLE	CROSS-SECTION ALONG STRIKE AT COAL SEAM JUNE 2020 CROSS-SECTION A-A'	
	PREPARED	REDMOND	PROJECT No.	923-1000-006	PHASE
	DESIGN				2020
	REVIEW				
	APPROVED				

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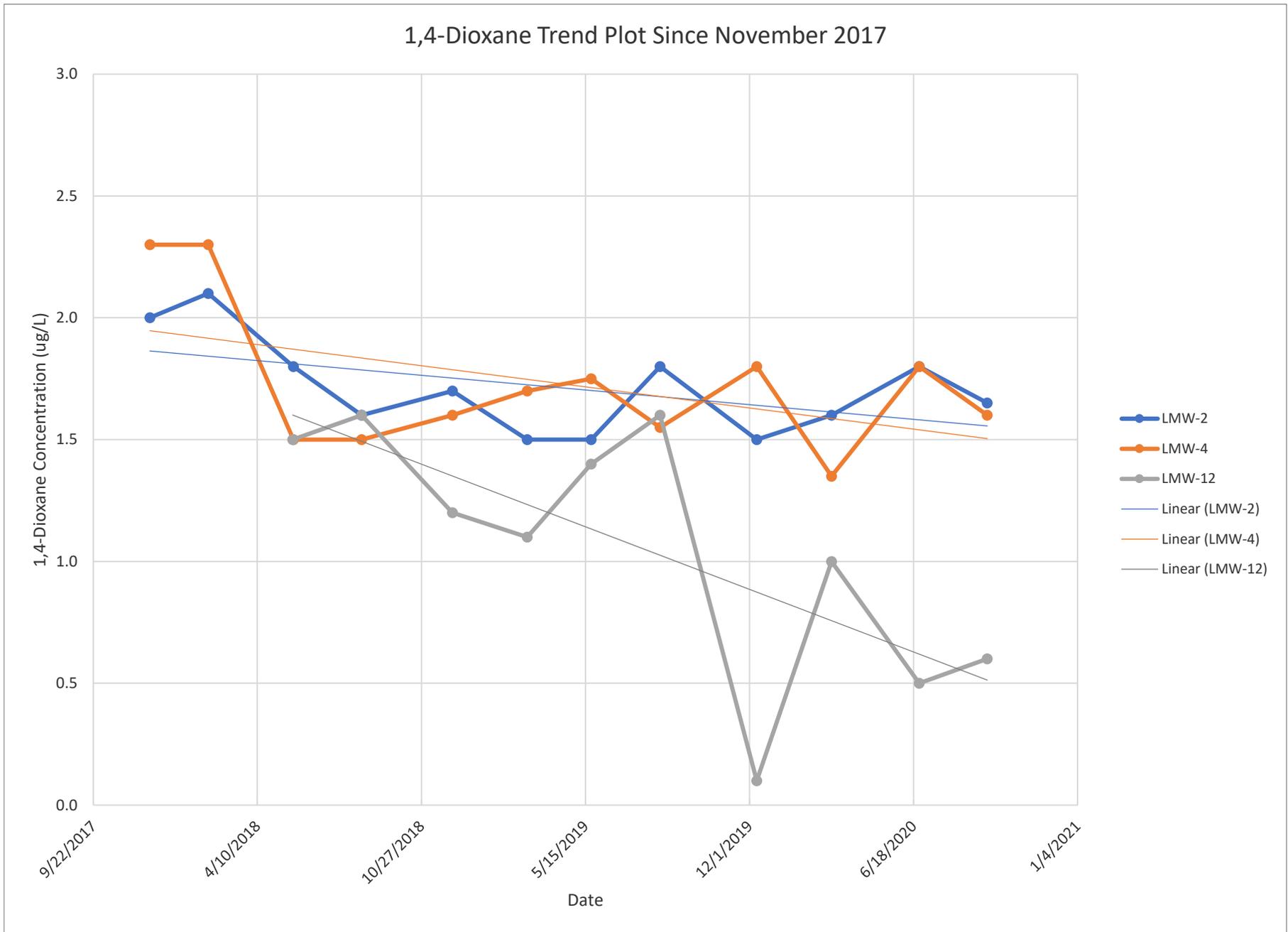


Figure 3: 1,4-Dioxane Trend Plot Since November 2017