Columbia River Project Water Use Plan

Arrow Lakes Reservoir Wildlife Management Plan

CLBWORKS-30C Arrow Lakes Reservoir Wildlife Enhancement Program – Physical Works

Reference: CLBWORKS-30C

2024 Burton Wetlands Engineering Monitoring & Inspection

Study Period: October 2021 to October 2024

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January 17, 2025

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Technical Memorandum

DATE: January 17, 2025

TO: Trish Joyce, Project Manager
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FROM: Kalie Siemens, P.Eng.

RE: **CLBWORKS-30C – WILDLIFE ENHANCEMENT PROGRAM AT BURTON FLATS**
2024 Burton Wetlands Engineering Monitoring & Inspection
Our File 0478.229-300

This memorandum summarizes the results of 2021-2024 water level monitoring and the spring 2024 engineering inspection for the Burton Flats wildlife enhancement program.

Many sections within this report have been retained from the 2022 Engineering Inspection and Monitoring report (KWL, 2022)[1] for completeness, but are largely unchanged with minor updates.

1. Introduction

1.1 Background

Kerr Wood Leidal Associates Ltd (KWL) was retained by BC Hydro in 2017 to provide engineering services for design and construction for the Burton Flats Wildlife Enhancement Project in collaboration with LGL Ltd. (LGL). Geotechnical investigation, analysis and design input were provided by Thurber Engineering Ltd, and hydrogeologic investigation, analysis, and design input were provided by Piteau Associates Ltd. The physical works are located south of Burton, BC on Burton Flats on the east side of the Arrow Lakes Reservoir. The project is a part of the CLBWORKS-30B Lower Arrow Lakes Reservoir Wildlife Enhancement program that seeks to create, protect, or enhance habitat for nesting and migratory birds and wildlife.

The Burton Flats physical works are intended to create a mixture of shallow and deep wetland habitat in the drawdown zone of the Lower Arrow Lakes Reservoir. The project utilizes high groundwater levels onsite, which came to surface in several areas prior to construction, including a groundwater fed watercourse. Groundwater monitoring at Burton Flats and surface water monitoring on Burton Creek have been ongoing since May 2017. Wetlands and ponds were created by excavation to and below the groundwater table, and the resulting excavated material was used to create high elevation habitat mounds above full reservoir water level.

Design and construction of the works were completed in two phases to evaluate the effectiveness of the design and habitat establishment of Phase 1 and to inform the design of Phase 2, and adjustments to Phase 1 works. Construction of Phase 1 took place in September and October 2019, and construction of Phase 2 was completed in April 2021. A summary of project phasing and components is provided in Table 1, and Figure 1 shows an overview of the constructed works.

[1] Kerr Wood Leidal Associates Ltd. (KWL). 2022 Burton Wetlands Engineering Monitoring and Inspection. Reference CLBWORKS-30B. Submitted November 16, 2022.

Table 1: Summary of Project Phasing

Phase 1 Constructed Works (Fall 2019)	Phase 2 Constructed Works (Spring 2021)
• Wetlands A1 and A2; • Approximately half of wetland A4; • Wetlands A3 and B1; and • Part of habitat mounds C2 and C3. *Wetlands A3 and B1 were planned for expansion in Phase 2 but were not widened, following Phase 1 monitoring and Phase 2 detailed design.* *Design for Phase 1 originally included an additional mound and part of pond D1, which were not completed due to high reservoir levels.*	• On site salvage and placement of fine wetland organics (muck) in all wetlands; • Adjustments to wetlands A2 and A3 (deepened); • Remainder of wetland A4; • Wetlands A5, A6, and B2; • Ponds D1 and D2; and • Remainder of habitat mounds C2 and C3. *Mounds C1 and C4 were originally planned for construction in Phase 2 but were removed from the design based on monitoring and Phase 2 detailed design.*

The primary engineering reference documents for the previous stages of the project are as follows:

- **Site Selection and Conceptual Design:** CLBWORKS-29B: Arrow Feasibility Study of High Value Habitat for Wildlife Physical Works. Update in 2016 by LGL; original 2012 Report by LGL and KWL;
- **Feasibility Design**: Wildlife Enhancement Program at Burton Flats: Feasibility Design Final Report. KWL, August 2017;
- **Phase 1 Detailed Design and Phase 2 Conceptual Design**: Wildlife Enhancement Program at Burton Flats: Detailed Design Final Report V2. KWL, October 2018;
- **Phase 1 Construction Completion**: Wildlife Enhancement Program at Burton Flats: Phase 1 Construction Completion. KWL, June 2020;
- **Phase 1 Monitoring and Phase 2 Detailed Design**: Wildlife Enhancement Program at Burton Flats: Phase 2 Detailed Design Report. KWL, March 2021;
- **Phase 2 Construction Completion**: Wildlife Enhancement Program at Burton Flats: Phase 2 Construction Completion. KWL, December 2021; and
- **Engineering Monitoring, Operations, and Maintenance:** Wildlife Enhancement Program at Burton Flats – CLBWORKS-30C. KWL, December 2021.

1.2 Scope

KWL's scope of work for this stage of the project included engineering monitoring and inspection over the first four years following Phase 2 construction, from 2021 to 2024. This includes the following:

- **2021 monitoring**: fall water level monitoring and analysis;
- **2022 monitoring and inspection**: spring water level monitoring, spring engineering inspection, survey of water level benchmarks, fall water level monitoring, and engineering inspection and monitoring memo;
- **2023 monitoring**: spring and fall water level monitoring; and
- **2024 monitoring and inspection**: spring and fall water level monitoring, spring engineering inspection, and engineering inspection and monitoring memo.

This memorandum summarizes the results of the 2021-2024 water level monitoring and Spring 2024 engineering inspection. Site visits for monitoring and inspection have taken place on the following dates:

Table 2: Monitoring and Inspection Dates

Date	Monitoring/Inspection
October 8, 2021	Monitoring
April 12-13, 2022	Monitoring and Inspection
September 20, 2022	Monitoring
April 5, 2023	Monitoring
September 21, 2023	Monitoring
April 17, 2024	Monitoring and Inspection
October 17, 2024	Monitoring

The detailed monitoring plan is described in Engineering Monitoring, Operations, and Maintenance Memorandum (KWL, 2021), and the monitoring objectives are summarized below.

1. Inspect and assess if the engineering physical works have experienced damage or deterioration, and recommend maintenance, if required.
2. Monitor and evaluate whether physical works are meeting engineering design basis targets. This includes target water depths and other design basis items summarized in the *Engineering Monitoring, Operations, and Maintenance Memorandum* (items 2, 3, 4, 5, 6, 8, and 10 from Section 1.3 of that document). Target water depths are summarized in Section 3 of this memorandum.
3. Identify and document potential insights and learnings from engineering monitoring for future similar projects in reservoir drawdown zones. This should include the following items in addition to others that may be identified during monitoring.
    a. Monitor and evaluate the impacts of the reservoir on the wetlands, ponds, and mounds and the performance of mitigation measures built into the design (mounds for wave protection, shallow slopes, wetland siting).
    b. Monitor and evaluate the effectiveness of water retention (surface water and groundwater) in the wetlands to meet design target water depths and consider future methods to reduce uncertainty in water levels prior to construction.
    c. Monitor and evaluate what, if any, features require greater maintenance or repair.

For the Fall 2024 monitoring visit, the scope was revised to include the reinstallation/relocation of the Burton Creek water level gauge, including provisions for new gauge materials and survey of the new gauge location and elevation. GreenStream Consulting Ltd., who completed the survey during the original construction, were retained to assist with the gauge relocation and survey of its new location. Details on the relocation are included in Section 4.

2. Spring 2024 Engineering Inspection

2.1 Inspection Scope

The engineering inspection includes assessment of all physical works constructed as part of the wildlife enhancement program at Burton Flats, including the following:

- Observed water levels compared to intended design levels;
- Wetland side slopes, bases, and water levels (slumping, erosion, sedimentation, water levels);
- Mound crest and slopes (slumping, erosion from wave action, cracking);
- Erosion protection (loss of rock, settlement, slumping, wave damage, downcutting);
- Outlet control structures (outlet channels, log structures, settlement, deterioration, sediment build up); and
- Habitat logs and LWD (wood loss, erosion of ballast soil).

Water level monitoring and assessment are described in Section 3, and the following subsections summarize the results of the engineering condition inspection. Inspection photos are included in Enclosure 1.

Overall, the works are performing well with no significant issues identified or recommended maintenance.

2.2 General Observations

No significant issues potentially impacting engineering works had been flagged prior to the 2024 inspection. Review of environmental monitoring results is not included with the engineering monitoring and inspection.

Below is a summary of general site observations from the inspection:

- Reservoir level during the inspection was between 429.21 m and 429.25 m elevation, based on the Fauquier gauge (WSC 08NE102) adjusted to the Burton site. This is lower than all the physical works.
- Weather during the inspection was sunny and cloudy and the site was free of ice and snow.
- Woody debris from the reservoir has deposited in the following locations at the site and is not negatively impacting the works:
    - along the side of the highway embankment in various locations;
    - immediately northeast of wetland A1; and
    - along the bottom of the slope of mound C2 on the southwest side.
- While there are signs of public use from recreational vehicles within the site footprint, there are no signs of damage to the physical works resulting from this.
- The pre-existing culvert and channel that flows from Burton Creek to pond D1 were not connected by surface water to the Burton Creek wetted channel during the inspection. Flow in the downstream channel was from groundwater.
- There is evidence of wildlife use in the area (bird footprints, various hoof prints, animal waste, etc.). This does not appear to be having any adverse impact on the engineering function of the works.

2.3 Wetlands

This section summarizes the engineering inspection results for all constructed wetlands. **Overall, the wetlands are generally meeting engineering design basis targets (except for wetland B1 which has consistently low water levels) and are in good condition, with no significant issues identified or recommended maintenance.** In general, water levels are lower in the late summer and fall than the spring, which was expected based on pre-construction monitoring. Lower water levels are more acceptable in the fall (see water level targets in Section 3), and deep pool areas were included in the shallow wetlands to provide deeper water areas during drier periods of the year.

Observations general to all wetlands are as follows, with wetland specific observations in sub-sections.

1. Side slopes, wetland habitat logs, outlet structures, inlets, and gravel armour were all in good condition with no issues noted.
2. The metal components of some of the piezometers show evidence of corrosion, staining, or "sludge" accumulating on the cable, crimps, and/or the sensor. This may be caused by a reduction-oxidation reaction with the groundwater. None of these items appear to be impacting the integrity of the piezometers.
3. Algae was present in many of the ponds.

Wetland A1

- During the inspection, the water level was approximately 0.3 m below the outlet level, and approximately in-line with the bottoms of the habitat logs. The inlet had water flowing over it from the pre-existing wetlands upstream.
- The logs, cobble, and larger rocks at the outlet all appear to be in good condition, with the logs and rock well embedded in the outlet side slopes and the cobble has been secured in place from fine sediment introduced from reservoir inundation.
- The wetland side slopes are well-vegetated with no signs of slumping or erosion.
- Grasses were growing at the wetted fringe of the wetland.

Wetland A2

- During the inspection, water levels were approximately 0.5 m below the bottoms of the wetland habitat logs. There was no inflow coming from Wetland A1 and there is no defined outlet for A2.
- The wetland side slopes are well-vegetated with no signs of slumping or erosion. Grasses are starting to grow on the island in the wetland, which is mostly covered with cobbles.
- There was small woody debris present on the island and at the south and east sides of the wetland. It appears to be mostly small fragments broken off of logs or larger woody debris from the reservoir. The woody debris did not appear to be impacting the engineering function of the works.

Wetland A3

- During the inspection, the water level was approximately 0.5 m below the bottom of wetland habitat log. There is no defined inlet or outlet for A3, and the side slopes were dry.
- The wetland side slopes are generally well-vegetated with no signs of slumping or erosion. Vegetation is absent below the bottom of the wetland habitat log, where the slope is covered with gravel. While this area is not presently eroding, it may be vulnerable to surficial erosion in the future. However, as this is a small area, significant impacts to the engineering function of the physical works are not anticipated if the area starts to erode.

Wetland A4

- During the inspection, the water level was approximately 3 cm above the log outlet and flowing into the downstream channel towards A5. There was no water flowing from the adjacent culvert through the highway embankment into A4.
- In general, the wetland side slopes are in good condition with no erosion or slumping observed. The wetland side slopes on the north and west sides are well-vegetated and steeper than the wetland side slopes toward the southeast edge, which are shallower by comparison and have more cobble and less vegetation.
- The outlet side slopes are gravelly and unvegetated. There is a small amount of grass in the outlet channel, but it is not impeding flow in the channel. The outlet is in good condition.

Wetland A5

- During the inspection, the water level was 2 cm above the log outlet and flowing into the downstream channel towards A6. Water was flowing into A5 from the outlet at A4.
- The wetland side slopes are well-vegetated with no signs of slumping or erosion.
- The outlet is in good condition as the log is well embedded into the outlet side slopes and the cobble has been secured in place from fine sediment introduced from reservoir inundation.
- In the channel between Wetlands A5 and A6, there is an unarmored, vegetated section where there appears to be some limited erosion as the side slopes are 0.1 m to 0.2 m tall and near vertical to overhanging. This does not appear to be introducing fine sediment into the channel or impeding flow from A5 to A6, and it does not appear to be impacting the engineering function of the works.

Wetland A6

- During the inspection, the water level was approximately 6 cm above the log outlet and flowing into the downstream channel towards D1. Water was flowing into A6 from A5.
- Grasses are growing in the inlet channel from A5, but this does not appear to be impeding the flow.
- In general, the wetland side slopes are in good condition with no erosion or slumping observed. There is noticeably less vegetation along the south and east edges of the wetland (near the inlet from A5) in comparison with the rest of the pond side slopes. The side slope gradients are generally consistent around the wetland.
- The pond outlet is in good condition, with the log well-embedded and the cobble appears well secured in the outlet side slopes. Grasses are starting to grow in the cobble.

Wetland B1

- During the inspection, water was only present in the deep pool of the constructed wetland, with a measured depth of 5 cm in the April 2024 site visit. The surface water elevation measured in the pond was lower than the groundwater surface elevation measured in the nearby piezometer. This opposes the historical trend in which the pond surface water level is higher than the water in the piezometer. The reason for this is unknown. During the Fall 2024 monitoring visit, both the pond and the piezometer were dry.
- There is very little vegetation growing within the wetland footprint. There is a distinct vegetation line around what is likely the historical high-water mark of this pond.
- The side slopes were sandy and dry. No erosion or slumping was noted along the side slopes. Some larger (approx. 150 mm) cobble was observed closer to the deep pool.

Wetland B2

- There are no surficial channels flowing into the wetland. A small amount of water was flowing out of the existing natural low point at the western edge of the wetland.
- There is less vegetation coverage on the side slopes than the other wetlands, potentially due to the lower elevation. There is sparse short grasses and cobble on the side slopes, which are notably shallower than the other wetlands.
- Minor erosion was observed on the south and east edges of the wetland. This is likely due to wind causing small waves predominantly in these directions over time. The erosion is not affecting the function of the wetland and does not presently present a risk to any of the surrounding works.

Pond D1

- During the inspection, water from Pond D1 was flowing through the downstream channel to Pond D2, with approximately a 9 cm water depth flowing through the channel. Seepage was observed from the slope on the upstream (south) side of the pond, and water was also flowing into the pond from the channel at the outlet of Wetland A6.
- There is an erosion feature that has formed at the southwest part of the pond, in the direction of the slope up to Mound C2. The erosion feature is approximately 2 m long and 30 cm deep. There appears to be groundwater seepage causing piping of the fine soils on this slope. The slope was saturated and very soft. Erosion was noted to have increased in the Fall 2024 monitoring visit; however, it seems to be limited to an area with fine soils and presently does not appear to be impacting the function of the works.
- The pond side slopes have very little vegetation, with sparse cobble and gravel coverage.
- Similar to Wetland B2, localized erosion due to wave action is observed at various locations around the pond edge. This is expected given the fine soils and absence of established vegetation. It does not appear to be having any significant impact on the pond or surrounding areas.
- Large woody debris was observed in the pond but is not impacting the engineering function of the works.

Pond D2

- During the inspection, water was exiting Pond D2 through the natural outlet downstream.
- Water was flowing into D2 from both D1 and the channel from B2.
- Similar to Wetland B2 and Pond D1, localized erosion due to wave action is observed at various locations around the pond edge. This is expected given the fine soils and absence of established vegetation. It does not appear to be having any significant impact on the pond or surrounding areas.
- Similar to B2 and D1, the side slopes have very little vegetation, with sparse cobble and gravel coverage.

2.4 Habitat Mounds

This section summarizes the engineering inspection results for all habitat mounds. **Overall, the habitat mounds are performing well with no significant issues identified or recommended maintenance.** Observations general to both habitat mounds (C2 and C3) are as follows.

- No signs of erosion were observed along the side slopes, toe, and crest of the mounds.
- No changes to the structure were observed (such as scour, settlement, loss of material). There is no evidence that recreational vehicle traffic is causing damage to the mounds.
- Snags, embedded large woody debris, and bat boxes all appeared in good condition with no noted issues.
- Most of the mound surfaces are covered with dense Reed Canary grass. Near the toe of mound C2 on the northwest side, there is a small area of bare sandy ground without vegetation. This is near the saturated slope with the erosion feature at D1.
- There is no change to the location or amount of woody debris that was observed to have deposited along the bottom of the southwest slope of Mound C2 in the 2022 inspection. This may be because Arrow Reservoir water levels in 2023 and 2024 were lower than other years in the monitoring period. The woody debris is not causing damage to the mound or impacting the engineering function of the physical works. Mound C2 is providing protection to the wetlands to the east from wood debris and wave action from the reservoir.

3. Water Level Monitoring

3.1 Monitoring Scope

Water level monitoring has been ongoing at the site since May 2017, with expansion of the monitoring system during construction. The original intent of the water level monitoring program was to inform design, while it now is used to assess whether the wetlands are meeting the design targets for water depth and availability. Seven post-construction water level monitoring site visits have been completed, with dates shown in Section 1.2. Water level monitoring includes the following, which is shown on Figure 2:

- Wetland piezometers:
  - wetlands A1 and A4 (2017 to present), and
  - wetlands A2, A3, and B1 (2019 to present).
- Manual wetland water depth measurements – all wetlands and ponds;
- Burton Creek piezometer and manual water depth measurement (2017 to present); and
- Piezometer 1 - groundwater piezometer west of site (2017 to present).

Rebar benchmarks installed by LGL that were previously used as additional reference points for manual wetland depth measurements have since been removed and are no longer used. Manual wetland water depth measurements are undertaken in accordance with KWL's *Water Level Data Collection Instructions – V2* Memo (2021). The only rebar benchmarks that are still used are the ones that were installed by KWL.

The pond water level elevations were surveyed during the Fall 2024 monitoring visit because survey equipment was on site for the relocation of the Burton Creek gauge. The typical manual depth measurement methods were also carried out for each of the ponds, which resulted in water levels that were in good agreement with the surveyed water levels (within 10 cm).

The following sections summarize the water level monitoring results to date in relation to the target water levels, along with a brief discussion on weather during the monitoring period relative to longer term climate normals.

3.2 Post-Construction Water Levels Relative to Targets (2021 – 2024)

The design basis water level targets for the wetlands are as follows:

- Target shallow wetland depths from 0.4 m to 1 m during high water and as low as 0.1 m to 0.6 m during low water, with variation between and within wetlands. Design deep pool areas with an approximate minimum area of 50 m^2 and maximum depth of 1 m. The overall average depth target is 0.3 to 0.5 m.
- Target deep waterfowl pond depths of 1 to 1.2 m with shallow fringes. Pond D1 was designed to be shallower than the original targets (0.6 to 1 m) for variability.
- April 1 to October 31 is the target habitat window; however, April to August is considered the most important time to retain a minimum depth for amphibians and lower water levels in the fall are not a significant concern.

Overall, the wetland water levels are generally meeting the design basis targets, except for wetland B1, which continues to have water levels below target. Wetland B1 generally only meets target depths immediately prior to and following inundation. Wetlands A1, A2, and A3 are generally within the lower range or slightly below the target depths (primarily 0.2 m to 0.6 m water depth), while wetlands A5, A6, and B2 are generally in the upper range or slightly above the target depths (primarily 0.4 m to 0.8 m water depth). One of the design basis objectives was to provide variability in water depths across wetlands, and as a result slightly higher or lower water levels are not necessarily an issue. Continued water level monitoring and environmental monitoring (completed by others) should be completed to consider whether higher water levels are having any negative impacts on environmental performance.

Generally, water levels in the constructed wetlands varied by 5 to 30 cm from the average water level throughout the year. During this period, groundwater levels in Piezometer 1 remained constant at approximately 434 m, increasing as reservoir levels reach groundwater levels. Water levels at the Burton Creek gauge ranged from 440.5 m to 441.8 m over this same period.

Table 3 below summarizes the average wetland water elevation and Figure 3 shows average water depth ranges within each wetland – both based on monitoring from 2021-2024. The full water level monitoring results for each of the wetlands, Burton Creek, and Piezometer 1 (groundwater west of site) are attached for 2021-2024 (see Enclosures 2, 3, 4, and 5) – representing the full period of record following the completion of both phases of construction.

Table 3: Summary of Average Wetland Water Elevation

Monitoring Method	Wetland	Average Bottom Elevation[a] (m)	Outlet Elevation (m)	Average Water Surface Elevation During Habitat Window[b,c] 2021-2024 (m)	Variability Range from Average Water Surface Elevation During Habitat Window[d] (m)
Piezometer	A1	437.9	438.5	438.17	+0.5 / -0.1
	A2	436.9[e]	438.1	437.05	+0.8 / -0.5
	A3	435.7	437.35	436.20	+1.2 / -0.3
	A4	435	435.5	435.58	+0.3 / -0.1
	B1	434.2	436.7	434.36	+2.3 / -0.5
Manual Measurements	A5	434.5	435.1	435.09	+0.1 / -0.2
	A6	433.9	434.46	434.51	+0.1 / -0.02
	B2	433.6	434.5	434.27	+0.1 / -0.1
	D1	432.8	433.65	433.62	+0.1 / -0.1
	D2	431.5	432.3	432.43	+0.4 / -0.1

a. Bottom elevation excludes deep pool areas.
b. Habitat window is April 1 to October 31.
c. Water elevation excludes periods where the wetlands are inundated by the reservoir and Phase 2 construction. Averages consider data up until October 17, 2024.
d. Variability is the deviation from the average water level. For wetlands without piezometers, this is based on the manual measurements.
e. A2 bottom elevation ranges from 436.7 m to 437 m elevation.

3.3 Comparison of Pre- and Post-Construction Water Levels (2017 – 2024)

Monitoring at four locations (A1, A4, Piezometer 1, and Burton Creek) has been ongoing since 2017, representing a longer-term record of water surface elevation levels around the site. The piezometers at A1 and A4 were installed prior to construction of the wetlands and were renamed following construction. These longer-term monitoring locations provide a comparison of pre and post construction conditions, and greater information on variability in water levels (though at a more limited number of locations). Enclosure 6 contains the long-term monitoring results for all years of record. The main points from review of this data are summarized below.

- **A1**: Water surface levels in the piezometer ranged from 438.03 m to 438.8 m elevation throughout a given year and over the years (excluding periods when inundated). There is no apparent difference in pre and post construction water elevations. Water levels were generally higher in the spring and lower in the fall.
- **A4**: Water surface levels had greater variability pre-construction, while post construction water levels have had very minimal variability. Pre-construction, water elevations ranged 435.7 m to 436.4 m, while post construction water elevations have ranged from 435.46 m to 435.86 m (excluding periods when inundated). This is to be expected given the A4 outlet spills water downstream at 435.5 m.
- **Burton Creek**: Water surface levels on Burton Creek are influenced by various climatic factors that contribute to discharge as well as the changes in channel geometry that occur in the area of the gauge. Where the gauge is located, the channel is braided and has shifted over time. Water elevations at the gauge have ranged from 440.3 m to 441.9 m over the monitoring period.
- **Piezometer 1 (west of site)**: For the majority of the years of record, groundwater levels have been 434 m +/- 0.2 m, increasing only when reservoir elevations reach and exceed this elevation. The exception to this is 2018, when groundwater levels were up to 435.5 m in the late spring.

Overall, the longer period of record shows that the wetland areas (represented by A1 and A4) have relatively small variations in water surface elevation compared to Burton Creek and the reservoir, and they are significantly higher than groundwater levels west of the site. This may be due to preferential groundwater flow paths through alluvial materials in the wetland areas (as the site was an active part of the Burton Creek fan prior to the highway construction).

Post construction, water levels in A1 (which generally has limited flow from its outlet) are similar to pre-construction levels, indicating the constructed works have not impacted the groundwater levels at the upper end of the site. Conversely, water levels in A4 post-construction have minimal variability and generally align with the wetland outlet level. This contrasts two design approaches and outcomes: one where the outlet is situated higher than typical groundwater levels (A1), which retains the natural variability, and the other where the outlet is situated near the lower range of typical groundwater levels, which lowers overall groundwater levels and reduces variability.

3.4 Weather and Climate During Monitoring Period

The monitoring period represents a relatively short snapshot in water level and weather conditions at the site. To provide context for the water levels relative to average historical climate conditions, conditions during the monitoring period (2017-2024) have been compared to either a station period of record or a climate normal (timeframe commonly used to represent average historical climate conditions for a particular location). This review considered the comparisons summarized in Table 4. The purpose of assessing climate conditions during the monitoring period relative to historical average climate conditions is to assess the influence of various climate conditions on Burton Creek flows, reservoir levels, groundwater conditions, and wetland and pond levels and the sensitivity to those influences.

Table 4: Data Sources and Historical Timeframes Referenced for Climate Assessment

Climate Metric	Data Source(s)	Historical Reference Period
Temperature, precipitation, and snow on the ground	Nakusp CS (Environment Canada ID 1145297)	1971-2000 Climate Normal
High elevation snowpack and snow water equivalent	Province of BC snow survey data from Barnes Creek (2B06P) and St. Leon (2B08P)	1992-2024 Period of Record (both stations)
Streamflow Hydrographs	Inonoaklin Creek above Valley Creek (WSC 08NE110)	1976-2022 Period of Record

Graphs of the climate data described above are shown in Enclosure 7. In general, across all the climate metrics considered, the monitoring period (2017-2024) captured a variety of climate conditions, where precipitation, temperature, snowpack, and streamflow had both high and low years relative to typical conditions. The exception to this is that summer and early fall temperatures have generally been similar to or higher than the climate normals in all years.

Generally, water levels at site rise in the spring in late March to early April, which coincides with the timing of low elevation snowmelt, spring precipitation, and modest increases in local river flows. Water levels typically stay high and gradually increase throughout the remainder of the spring and early summer, as creek levels peak and the reservoir level increases.

Based on this review, Table 5 summarizes a yearly comparison of climate conditions over the monitoring period. This considers those factors that are expected to impact water levels during the target habitat window (April 1 to October 31).

Table 5: Yearly Assessment of Climate Conditions Relative to Historical Average Conditions over the Monitoring Period

Year	Comparison to Historical Average Climate Conditions (Expressed as % of Normal Precipitation)	Notes on Snowpack and Freshet
2017	Spring – 179% Summer/fall – 26%	Low to average snowpack, but high freshet flows associated with rapid May snowmelt
2018	Summer – 63% Fall – 154%	Average to high snowpack and high freshet flows 2018 had the highest groundwater levels over the monitoring period
2019	Spring – 70% Fall – 120%	Low snowpack and low freshet flows
2020	Spring – 89% Summer – 79%	Average to high snowpack and high freshet flows
2021	Spring – 60% Fall – 173%	Average snowpack and freshet flows
2022	Average spring Summer – 42%	High snowpack and freshet flows
2023	Spring – 89% Fall – 68%	Low snowpack, high freshet flows
2024	Spring – 78% Fall – 122%[1]	Low snowpack (close to historic minimum)

1. Fall 2024 value considers data up to the end of November 2024.

With this range in climatic conditions, the site groundwater levels in the areas of the wetlands have varied insignificantly even with wetter and drier years on record, suggesting that groundwater availability and level is relatively independent of weather and climate fluctuations.

3.5 Reservoir Inundation

Enclosure 8 contains figures that show the design elevations of the wetlands and the typical periods of inundation by the reservoir for each wetland. This analysis was originally completed during design, and it has been updated to reflect constructed elevations and additional years of reservoir data. Water levels are shown for the average, 25th percentile, and 75th percentile for the entire period of record (1970-2024) and for the period of record from 2000-2022, as BC Hydro has indicated that reservoir management policies from the year 2000 onward are more reflective of current and expected future operations.

For the purpose of this assessment, inundation is defined as the reservoir level exceeding the outlet elevation. The wetland water levels are influenced by reservoir levels prior to inundation. The wetlands are typically inundated for varying timeframes each year although some of the higher wetlands (A1-A3) were not inundated in 2024, and the length of inundation increases for lower wetlands and ponds.

3.6 Summary

The constructed wetlands are meeting the water level design basis targets for the project, with the exception of wetland B1, which has water levels well below targets. As noted in Section 3.2, several of the wetlands have water depths 5 to 20 cm above (A4, A5, A6, and B2) or below (A2) target water depths. One of the design basis objectives was to provide variability in water depths across wetlands, and as a result slightly higher or lower water levels are not necessarily an issue. Continued water level monitoring and environmental monitoring (completed by others) should be completed to consider whether higher water levels are having any negative impacts on environmental performance.

Within the habitat window (April 1 to October 31), water levels vary by as much as 40 cm (excluding periods when inundated), with the greatest variation in the upper-most wetlands (above A4). All wetlands have been inundated at least twice since constructed and are expected to be inundated annually for varying periods of time (see Section 3.5). Wetlands A1, A2 and A3 were not inundated in 2024 as reservoir levels were notably lower than previous years.

The monitoring period has captured a variety of climactic conditions that may be observed at the site in the future, suggesting that groundwater availability and level is not very sensitive to weather and climate fluctuations.

4. Burton Creek Gauge Relocation

The Burton Creek water level gauge was originally constructed as a PVC standpipe piezometer partially embedded in the creek bed and attached to a fallen log with ropes and hose clamps. The Burton Creek gauge did not have a metal casing like the wetland piezometers. Over time the condition of the fallen log had continued to deteriorate to a rotted state, leading to concerns that the log would no longer provide adequate support to the Burton Creek gauge and, if the log had failed, the attached gauge would be damaged or washed down the creek. Following the Spring 2024 inspection, these concerns were discussed with BC Hydro and through a subsequent change order, additional scope was provided to relocate and secure the gauge so that it was no longer attached to the rotting log.

During the Fall 2024 monitoring visit, the ropes and hose clamps attaching the log to the gauge were removed and the log and other debris were cleared from the area surrounding the gauge. Although the original intent was to relocate the gauge, the PVC pipe was found to be in good condition and securely embedded into the creek bed. Therefore, the gauge was left in place and secured with additional supports. Three T-posts were installed in the creek bed and bank to anchor the gauge. The posts were secured to the gauge with metal hose clamps and U-bolts. The top of the PVC pipe was re-surveyed to capture any shifting or movement resulting from installing the additional supports. The works resulted in a minor shift of the top of the pipe elevation from 441.75 m to 441.78 m. Pictures of the gauge before and after rehabilitation are shown in Photo 1 and Photo 2 below, respectively.

Photo 1: 2024-04-17 Gauge attached to rotting log

Photo 2: 2024-10-17 Gauge after Relocation

5. Conclusions

This memorandum documents engineering inspection and water level monitoring at the Burton Flats wildlife enhancement physical works that has been ongoing since construction completion in Spring 2021. This has included seven water level monitoring site visits (four in the Fall and three in the Spring) and two engineering inspections (Spring 2022 and Spring 2024). Wildlife use and vegetation monitoring has been conducted separately, by others.

The conclusions from engineering monitoring and inspection are prepared relative to the objectives listed in Section 1.2 and are provided below.

1. The engineering physical works are in good condition and have not experienced significant damage or deterioration. As a result, there is no recommended maintenance.
2. Constructed wetlands and deep ponds are generally meeting target water depths (design basis targets 3, 5, and 6 – see the *Engineering Monitoring, Operations, and Maintenance Memorandum)*, with some exceptions as noted in Conclusions #3 and #4. The wetland water levels are generally shallower and more variable in upper wetlands (A1-A3) and deeper and more consistent in lower wetlands (A5, A6, and B2).
3. Several of the wetlands have water depths 5 to 20 cm above (A4, A5, A6, and B2) or below (A2) target water depths. One of the design basis objectives was to provide variability in water depths across wetlands. These variances from the target depths do not raise any concerns from an engineering perspective as they do not appear to be impacting the physical works or having adverse environmental impacts.
4. Wetland B1 continues to have water levels below the target range and is not functioning as designed or anticipated. B1 was originally planned to be a larger pond, but following Phase 1, it was decided not to expand B1 due to low water levels. As wetland B1 was not designed to have inflow or outflow connecting to any other ponds and does not appear to be impacting any of the surrounding physical works including Mound C2, no remedial measures are recommended at this time, although monitoring and inspection of this wetland may continue. If more consistent water levels are desired, deepening the wetland could be considered with input from a qualified professional(s).
5. Based on the condition of the physical works, the variability of water levels within Arrow Reservoir do not appear to be impacting the engineering function of the wetlands and mounds. The areas where woody debris has accumulated from the reservoir do not appear to be having any adverse impact on the physical works. The erosion feature at Pond D1 is thought to be caused by subsurface groundwater flow, although this has not been investigated through engineering assessment. The works will likely continue to be inundated annually unless there are significant changes in dam or reservoir operations.
6. The design configuration included wetlands with and without connectivity, varying side slopes, variations in geometry, and large woody debris – to allow for comparative study of performance and increase the diversity of habitat (design basis targets 2, 4, 10 – see the *Engineering Monitoring, Operations, and Maintenance Memorandum)*. The varying types of features and geometry are all in good condition and are performing as designed and anticipated.

7. The habitat mounds were designed to protect the wetlands from waves and debris, increase habitat complexity, and provide higher elevation nesting habitat (design basis target 8 – see the Engineering Monitoring, Operations, and Maintenance Memorandum). The mounds are in good condition and meeting their intended engineering function (including accumulating debris that may otherwise have reached the wetland areas). Nesting activity and vegetation are outside of the scope of engineering monitoring and may be commented on as part of wildlife and vegetation monitoring by others.
8. The manual measurement methods typically used in the monitoring site visits to estimate the water surface elevations for the wetlands and ponds have provided good accuracy for the purpose of this assessment, based on comparison with water surface elevations obtained from survey.
9. Using a primarily groundwater source for wetlands in reservoirs within the drawdown down has proven to be effective at retaining water levels within a reasonable target range and likely less sensitive to climactic variability than a surface water driven wetland.

6. Recommendations

This memorandum concludes KWL's four-year engineering inspection and monitoring period for the project. The following are recommended moving forward:

1. Continue engineering monitoring and inspection as outlined in KWL's *Engineering Monitoring, Operations, and Maintenance Memo* (2021). This specifically includes:
    a. Inspection (general site overview, wetlands, and habitat mounds) every 5 years or following any major events (such as prolonged flooding, heavy rainfall or high streamflow events) by a qualified professional; and
    b. Monitoring of wetland water levels annually in the spring. Alternatively, monitoring can continue to occur in both the spring and fall. Monitoring should occur at least once annually to inspect instrumentation for damage, low storage or battery life, etc.
2. Monitor the erosion that is occurring on the south slope of Pond D1. The erosion if not presently a concern as it does not appear to be presently impacting the function of the works. However, if the erosion continues above the high-water line/edge of vegetation, input from a qualified professional should be sought to recommend remedial measures, which may include placing coarse granular material along the slope and eroded areas to prevent cutback into Mound C2 and/or connection to an upstream pond. This feature should be inspected during the yearly (or twice-yearly) monitoring visits in the Spring to note potential increases in the rate of erosion.
3. Monitor the edges of Wetland B2 and Ponds D1 and D2 up to their respective high-water marks for signs of worsening impacts due to wave-induced erosion, such as impacting inlet or outlet function, or eroding back to another feature such as a pond, mound, or channel. These ponds are more susceptible to erosion from wave action given the lack of established vegetation and the exposed fine soils on their slopes. Increase of established vegetation that may occur with time, or placement of similar cobble material to what is observed at some of the inlet and outlet channels may potentially reduce this erosion.
4. If new issues are observed in subsequent monitoring visits that are impacting the engineering function of the physical works, retain the input of a qualified professional to assess the issues and make recommendations for monitoring, maintenance, or repair.
5. If changes in water level trends are observed in subsequent monitoring and target water levels are no longer being met, retain the input of a qualified professional to assess potential causes and make recommendations, if warranted.
6. Due to increased vegetation around the side slopes of some of the wetlands and ponds, reference markers such as piezometer casings and rebar are becoming increasingly difficult to locate in the field without survey equipment. BC Hydro may consider making these locations more noticeable such as with a tall reflective marking or similar. Alternatively, field staff can bring a smartphone with the Field Maps app, or GPS or similar to locate the benchmarks.
7. As part of continued water level monitoring, metal components of the instrumentation such as cables, crimps, and sensors should be replaced if excessively compromised by corrosion or chemical build-up from reaction with the groundwater.
8. Signage in the project area should be maintained for public awareness of the works and ongoing monitoring.

7. Submission

KERR WOOD LEIDAL ASSOCIATES LTD.

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KS/SFJ/tdl

Encl.: Figure 1: Overview of Constructed Habitat Works at Burton Flats
Figure 2: Burton Wetlands - Water Level Monitoring Locations
Figure 3: Average Wetland Water Depth
Enclosure 1: Engineering Inspection Photos
Enclosure 2: 2021 Water Level Monitoring Results
Enclosure 3: 2022 Water Level Monitoring Results
Enclosure 4: 2023 Water Level Monitoring Results
Enclosure 5: 2024 Water Level Monitoring Results
Enclosure 6: 2017-2024 Water Level Monitoring Results
Enclosure 7: Summary of Local Climatic Conditions
Enclosure 8: Long Term Reservoir Elevations

Statement of Limitations

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This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

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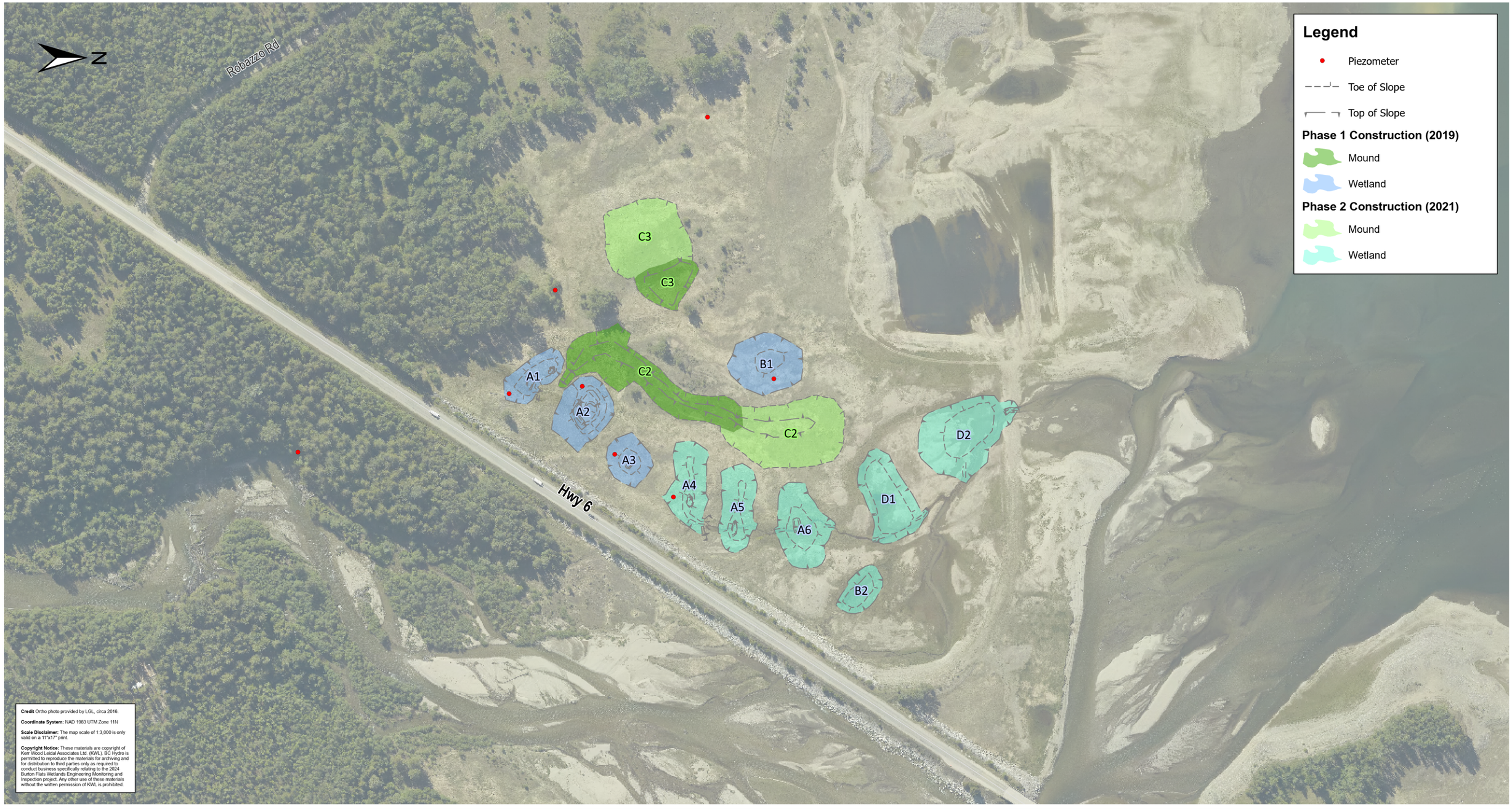
Revision History

Revision #	Date	Status	Revision Description	Author
0	January 17, 2025	FINAL	FINAL Memorandum	KMS

BC Hydro

2024 Burton Flats Wetlands Engineering Monitoring and Inspection

KERR WOOD LEIDAL consulting engineers



Credit Ortho photo provided by LGL, circa 2016.

Coordinate System: NAD 1983 UTM Zone 11N

Scale Disclaimer: The map scale of 1:3,000 is only valid on a 11"x17" print.

Project No. 478.229

Date January 2025

Scale 1:3,000

0 25 50 100 Meters

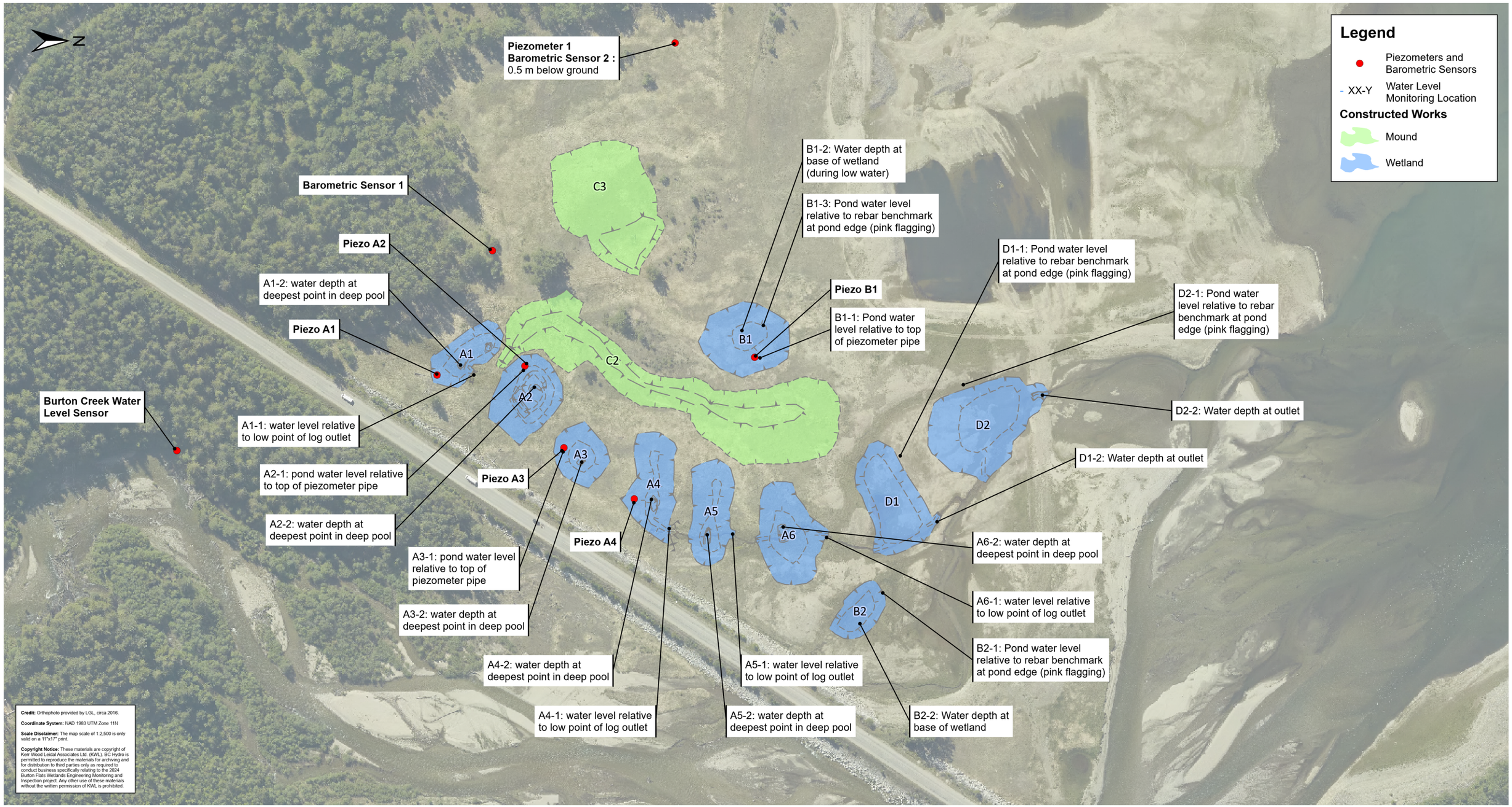
Overview of Constructed Habitat Works at Burton Flats

Figure 1

BC Hydro

2024 Burton Flats Wetlands Engineering Monitoring and Inspection

KERR WOOD LEIDAL consulting engineers



Credit: Orthophoto provided by LGL, circa 2016.

Coordinate System: NAD 1983 UTM Zone 11N

Scale Disclaimer: The map scale of 1:2,500 is only valid on a 11"x17" print.

Project No. 478.229

Date January 2025

Scale 1:2,500

0 25 50 100 Meters

Burton Wetlands - Water Level Monitoring Locations

Figure 2

BC Hydro

2024 Burton Flats Wetlands Engineering Monitoring and Inspection

KERR WOOD LEIDAL consulting engineers

Legend

- Surface Contours (0.5 m Interval)
- Wetland Outline

Average Water Depth 2021-2024 During the Habitat Window April 1 to October 31 (m)

- 0 - 0.2
- 0.201 - 0.4
- 0.401 - 0.6
- 0.601 - 0.8
- 0.801 - 1
- 1.001 - 1.2
- 1.201 - 1.4
- 1.401 - 1.6

Water depths shown are based on the average water depth during the Habitat Window (April 1 - October 31, 2021-2023 and April 1 - October 17, 2024), excluding periods of reservoir inundation. Wetlands A1, A2, A3, A4, and B1 are based on continuous monitoring with piezometers, and wetlands A5, A6, D1, D2, and B2 are based on manual measurements during site visits.

Water depths vary by +/- 20 cm to 30 cm from the average in wetlands A1, A2, A3, and B1.

In all other wetlands, water depths vary by +/- 5 to 10 cm from the average.

Note: 2016 aerial imagery shown.

Project No. 478.229

Date January 2025

Scale 1:1,250

0 10 20 40 m

Average Wetland Water Depth

Figure 3

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Enclosure 1

Engineering Inspection Photos

Enclosure 1 – Engineering Inspection Photos

Photo 1: Piezometer 1 Standpipe

Photo 2: Barometer 1 Sensor Hanging from Tree

Photo 3: Water Flowing into Wetland A1, Looking North

Photo 4: Wetland A1 and Piezometer, Looking West

Photo 5: Outlet of Wetland A1, Looking South

Photo 6: Woody Debris Deposited South of A1

Enclosure 1 – 2024 Engineering Inspection Photos

Photo 7: Wetland A2 and Piezometer, Looking East

Photo 8: Woody Debris in Wetland A2

Photo 9: Wetland A2 Island, Looking North

Photo 10: Wetland A3 and Piezometer, Looking East

Photo 11: Embedded Log at South Edge of A3

Photo 12: Wetland A3, Looking North

Enclosure 1 – 2024 Engineering Inspection Photos

Photo 13: Wetland A4 and Piezometer, Looking West

Photo 14: Wetland A4 Outlet, Looking South

Photo 15: Wetland A4, Looking East

Photo 16: Highway Culvert Near A4

Photo 17: Wetland A5, Looking East

Photo 18: Water Flowing North from A4 to A5

Enclosure 1 – 2024 Engineering Inspection Photos

Photo 19: Wetland A5 Outlet

Photo 20: Minor Erosion in Channel from A5 To A6

Photo 21: Wetland A6, Looking Northeast

Photo 22: Wetland A6 Outlet

Photo 23: Wetland B1 and Piezometer, Looking West

Photo 24: Wetland B1 Deep Pool

Enclosure 1 – 2024 Engineering Inspection Photos

Photo 25: Wetland B1, Looking East

Photo 26: Wetland B2, Looking Northeast

Photo 27: Wetland B2, Looking North

Photo 28: Minor Wave Erosion at South Edge of B2

Photo 29: Highway Culvert Flowing Towards B2

Photo 30: Pond D1, Looking Northeast

Enclosure 1 – 2024 Engineering Inspection Photos

Photo 31: Channel Flowing from B2 towards D2

Photo 32: Minor Wave Erosion at D1

Photo 33: Erosion Feature at South End of D1, Potentially Caused by Groundwater

Photo 34: Increase in Erosion Observed at South End of D1 During Fall Visit (October 17, 2024)

Photo 35: Pond D2, Looking Northwest

Photo 36: Inlet Channel From B2/D1 To D2.

Enclosure 1 – 2024 Engineering Inspection Photos

Photo 37: Pond D2, Looking Northeast

Photo 38: D2 Outlet Channel, Looking North

Photo 39: Burton Creek Gauge (prior to securing the gauge during the fall visit)

Photo 40: Burton Creek Gauge Following Re-Securing During Fall Visit (October 17, 2024)

Photo 41: West Side Of Mound C2

Photo 42: Top of Mound C2, Looking South Toward Mound C3

Enclosure 1 – 2024 Engineering Inspection Photos

Photo 43: Top of Mound C3, Looking Northeast

Photo 44: Bat Box On Mound C3

Photo 45: Wetland A1, Looking East From Hwy 6

Photo 46: Wetland A2, Looking East From Hwy 6

Photo 47: Wetland A3, Looking East From Hwy 6

Photo 48: Wetland A4, Looking East From Hwy 6

Enclosure 1 – 2024 Engineering Inspection Photos

Photo 49: Wetland A5, Looking East From Hwy 6

Photo 50: Wetland B2, Looking North from Hwy 6

Photo 51: Wetland A6 and Ponds D1 and D2, Looking Northeast from Hwy 6

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Enclosure 2

2021 Water Level Monitoring Results

Pond A1

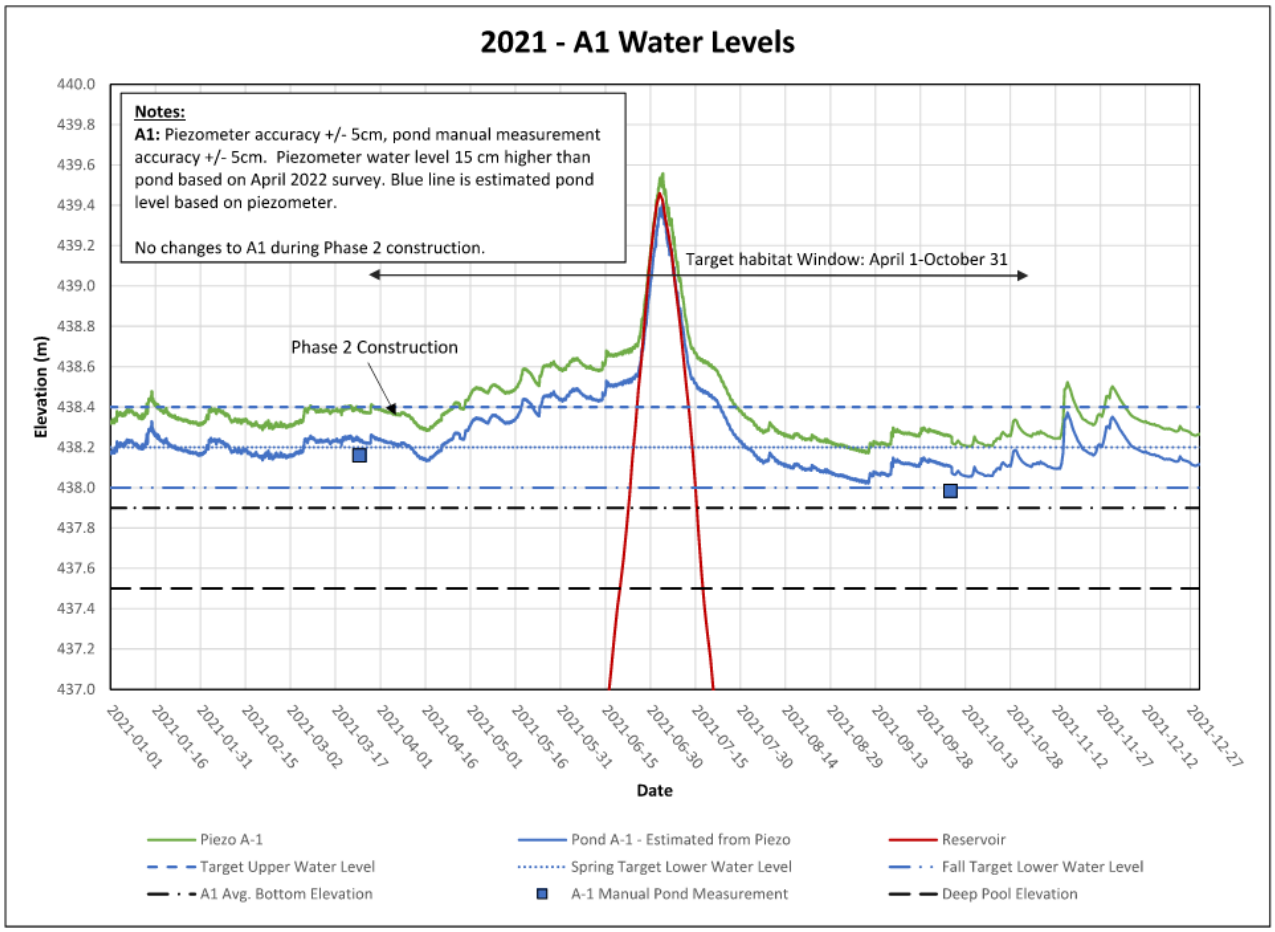

Photo 1: 2021-03-25 Pond A1

Photo 2: 2021-10-08 Pond A1

Pond A2

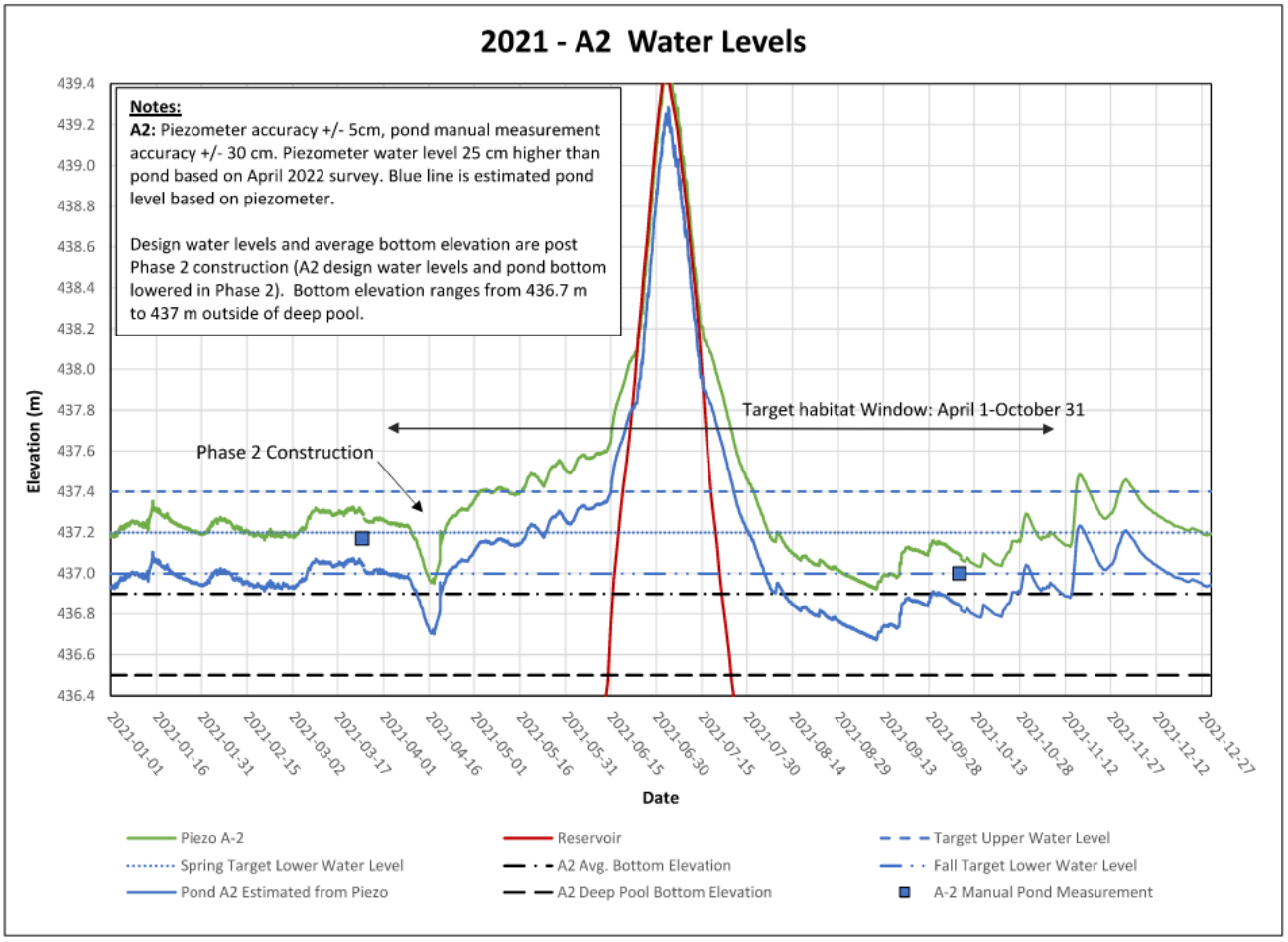

Photo 1: 2021-03-25 Pond A2

Photo 2: 2021-10-08 Pond A2

Pond A3

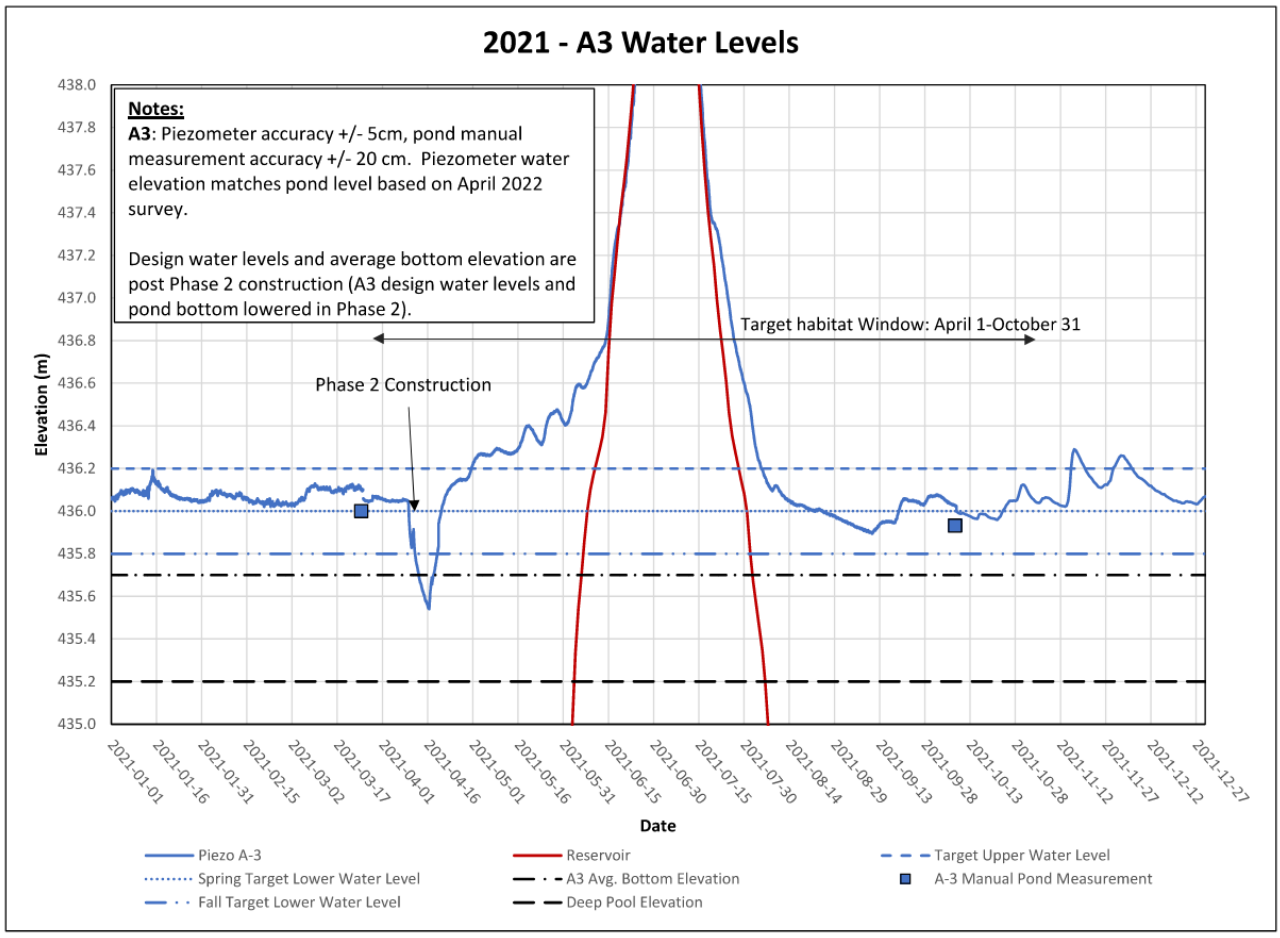

Photo 1: 2021-03-25 Pond A3 Pre-Construction

Photo 2: 2021-10-08 Pond A3

Pond A4

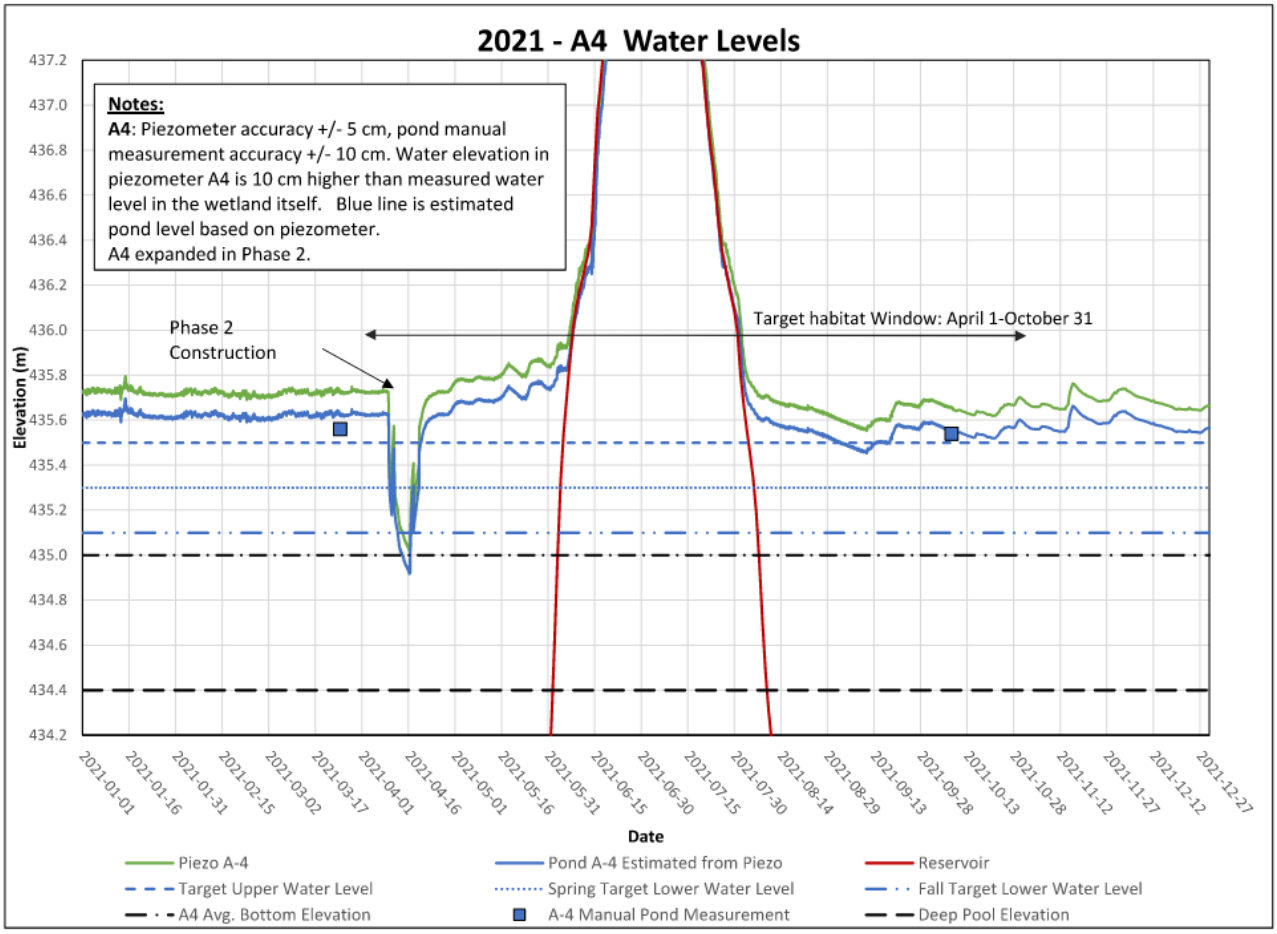

Photo 1: 2021-03-25 Pond A4

Photo 2: 2021-10-08 Pond A4

Pond A5

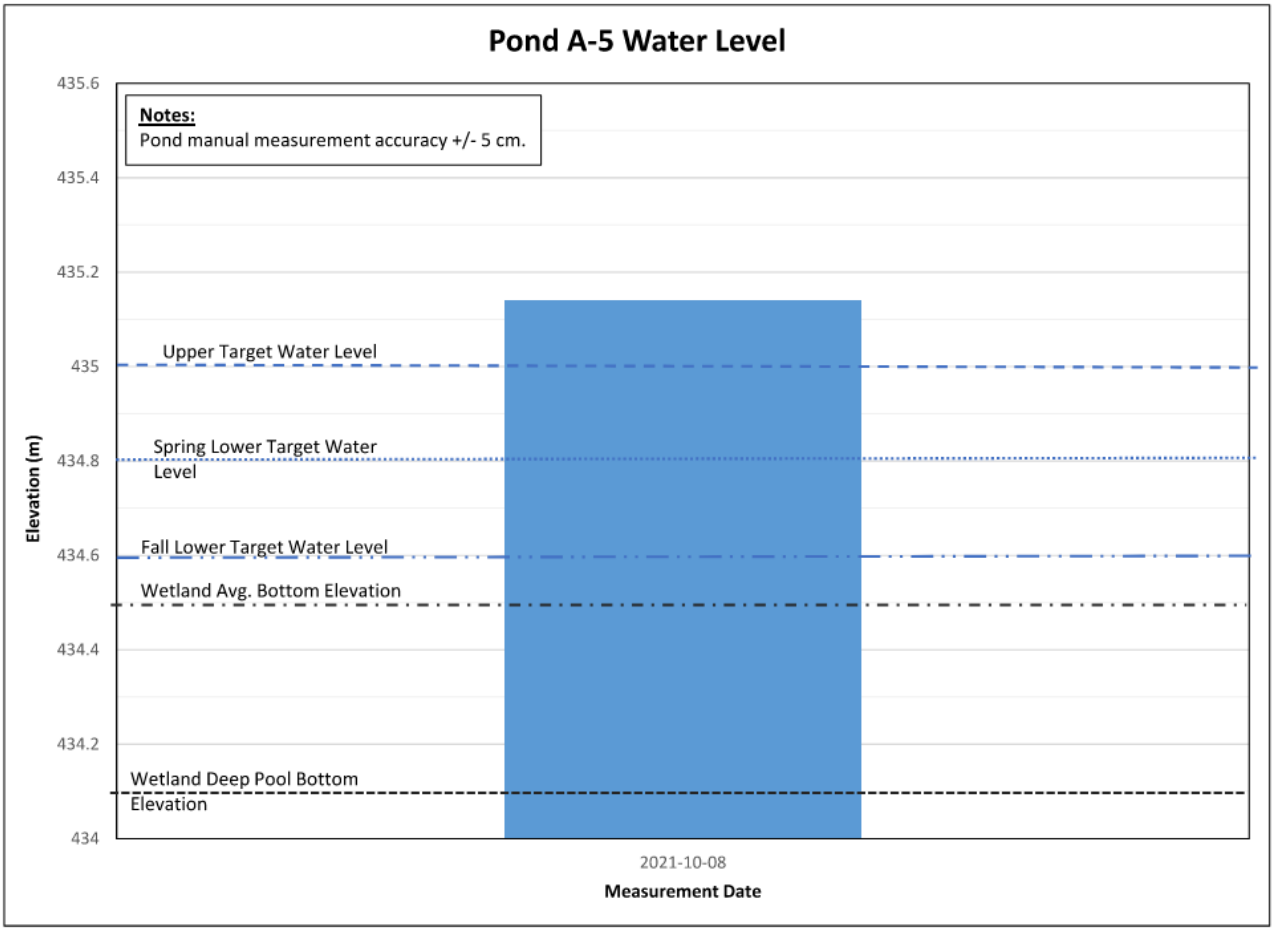

Photo 1: 2021-10-08 Pond A5

Pond A6

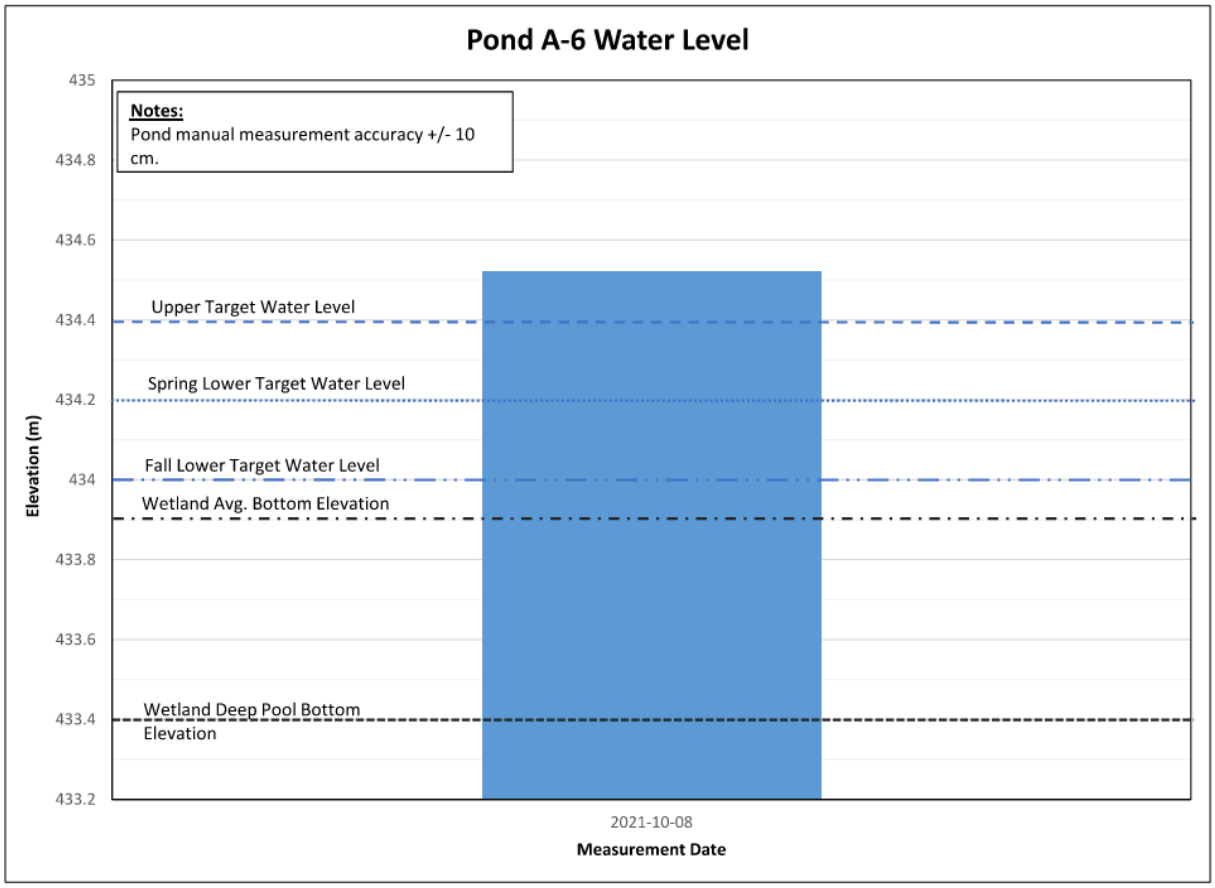

Photo 1: 2021-10-08 Pond A6

Pond B1

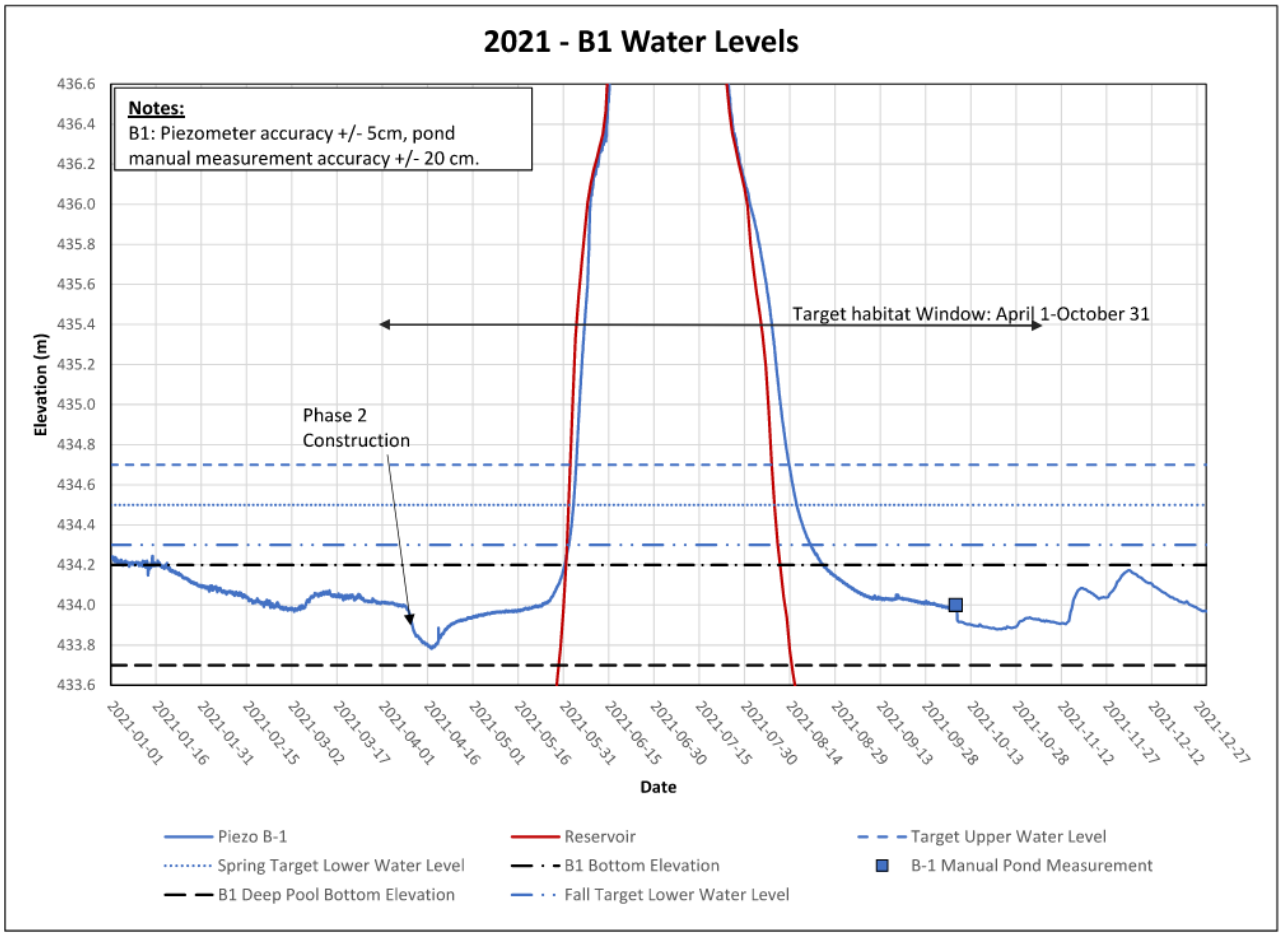

Photo 1: 2021-03-25 Pond B1

Photo 2: 2021-10-08 Pond B1

Pond B2

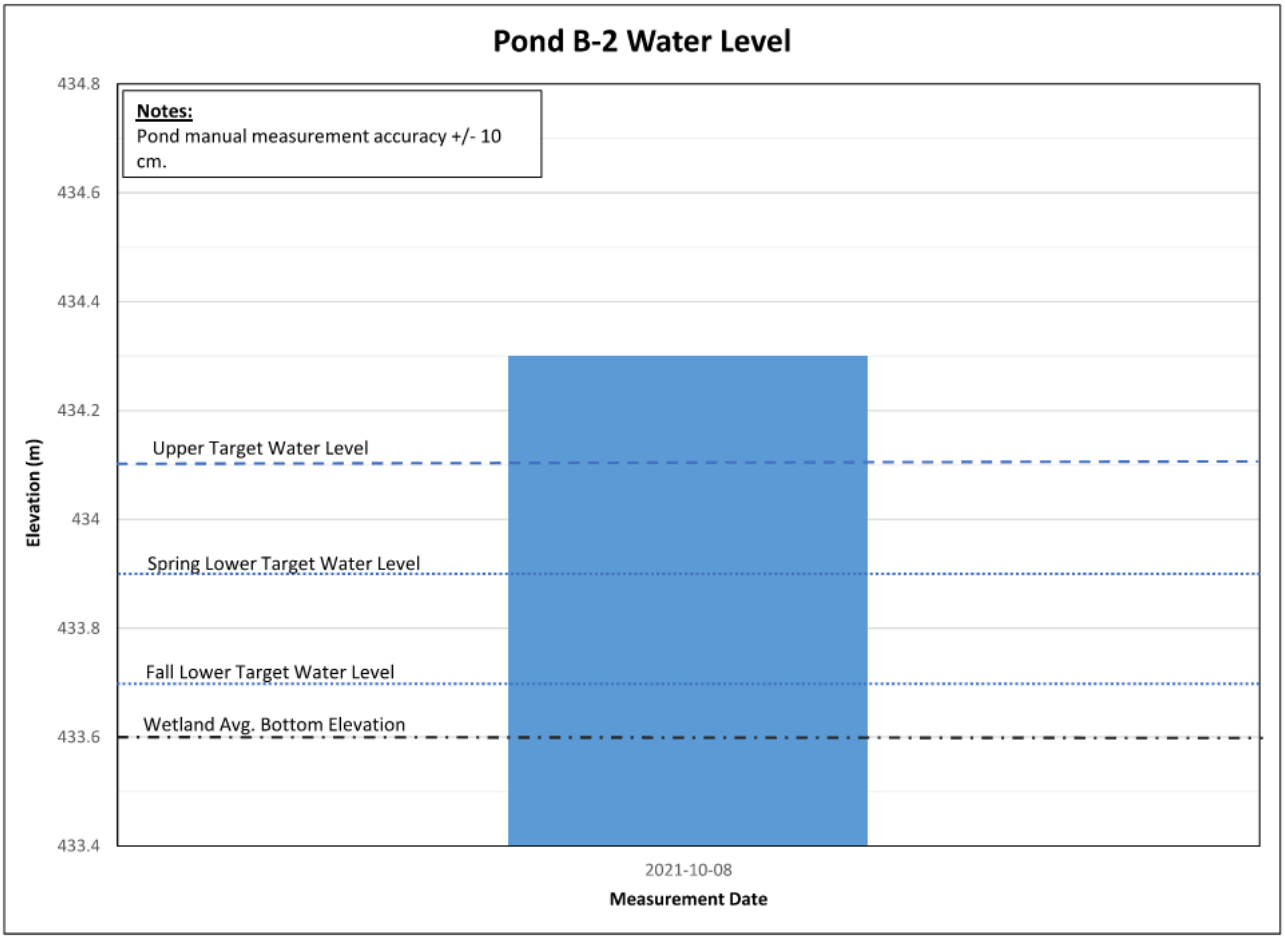

Photo 1: 2021-10-08 Pond B2

Pond D1

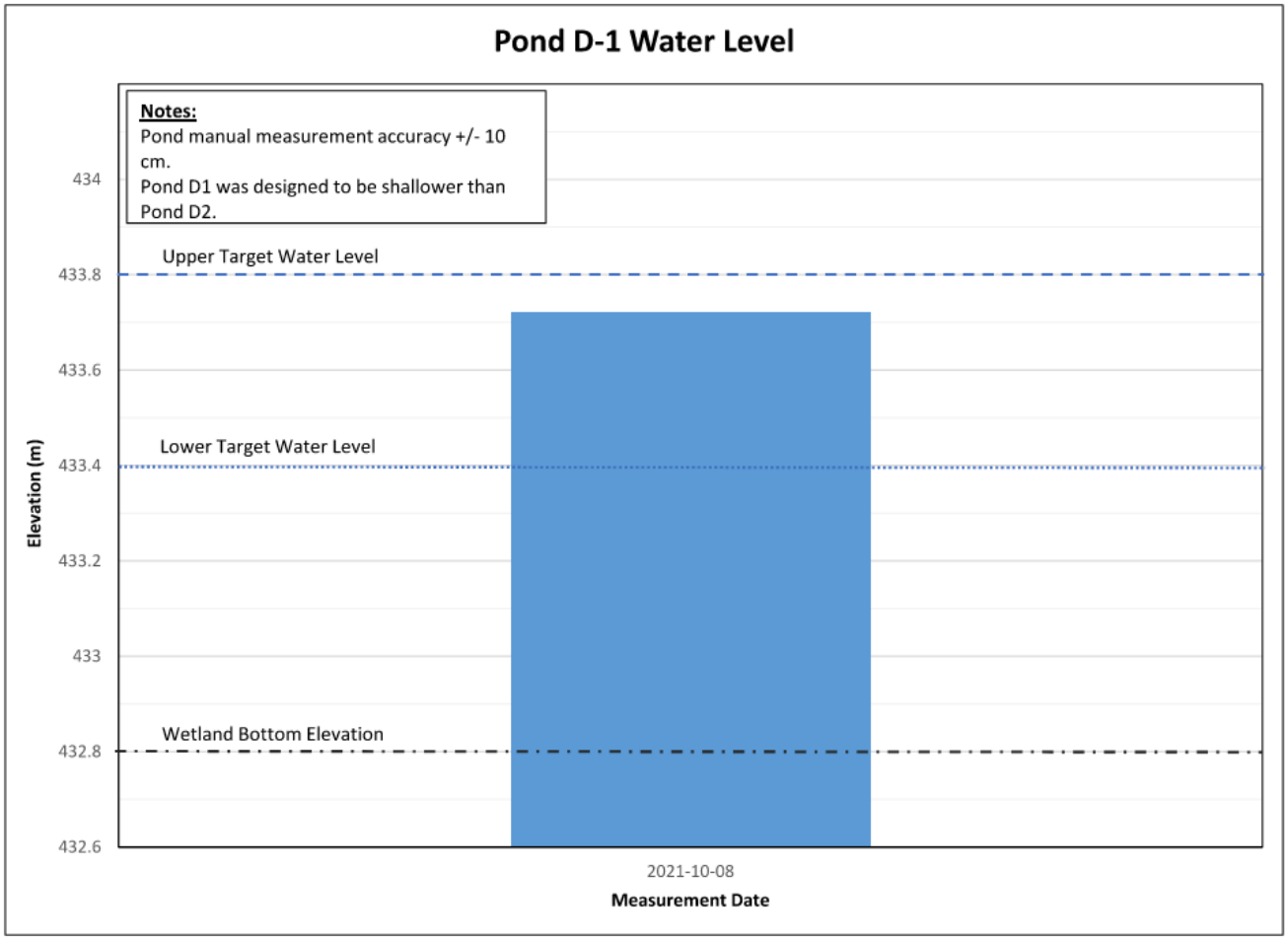

Photo 1: 2021-10-08 Pond D1

Pond D2

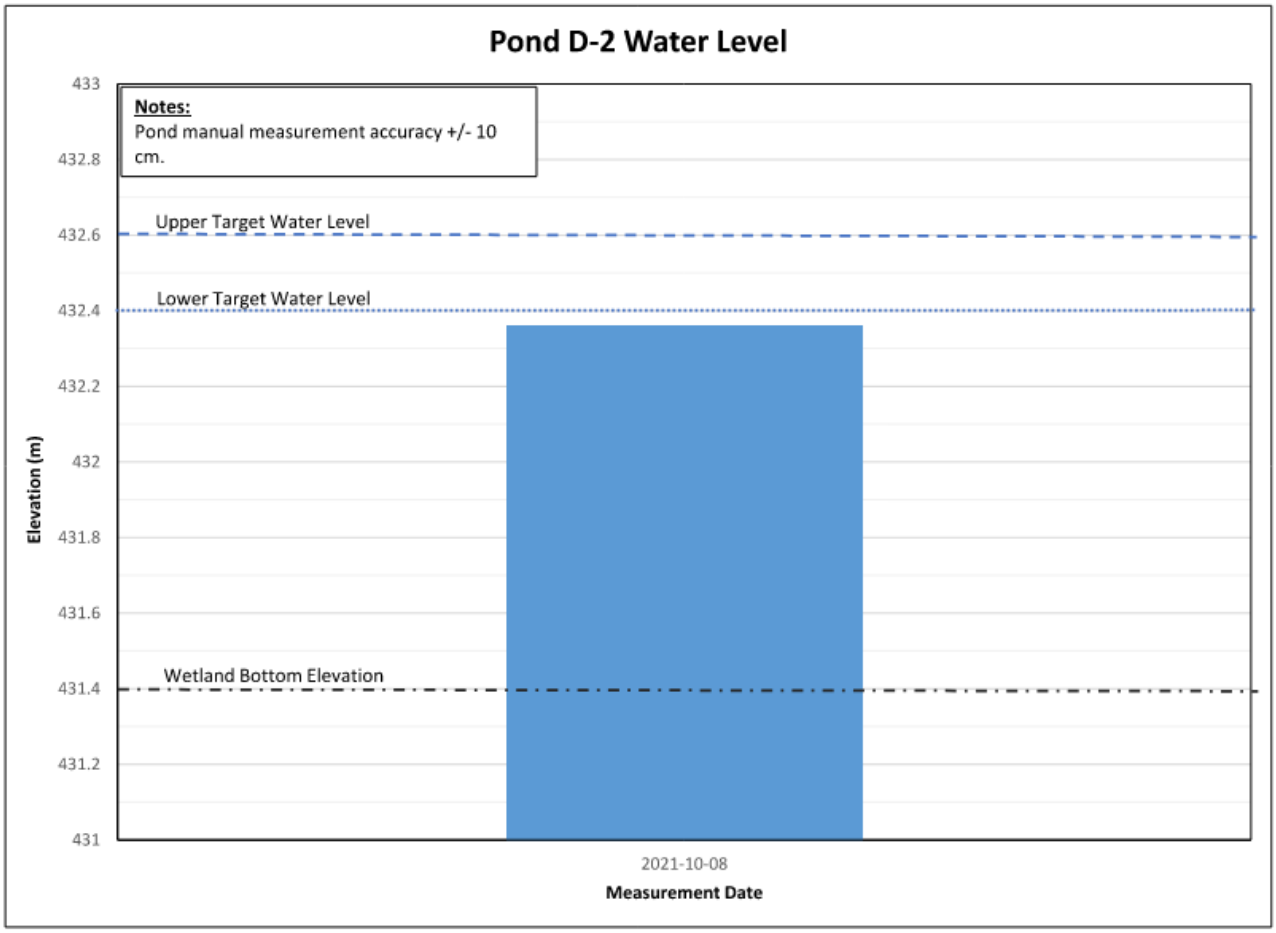

Photo 1: 2021-10-08 Pond D2

Burton Creek

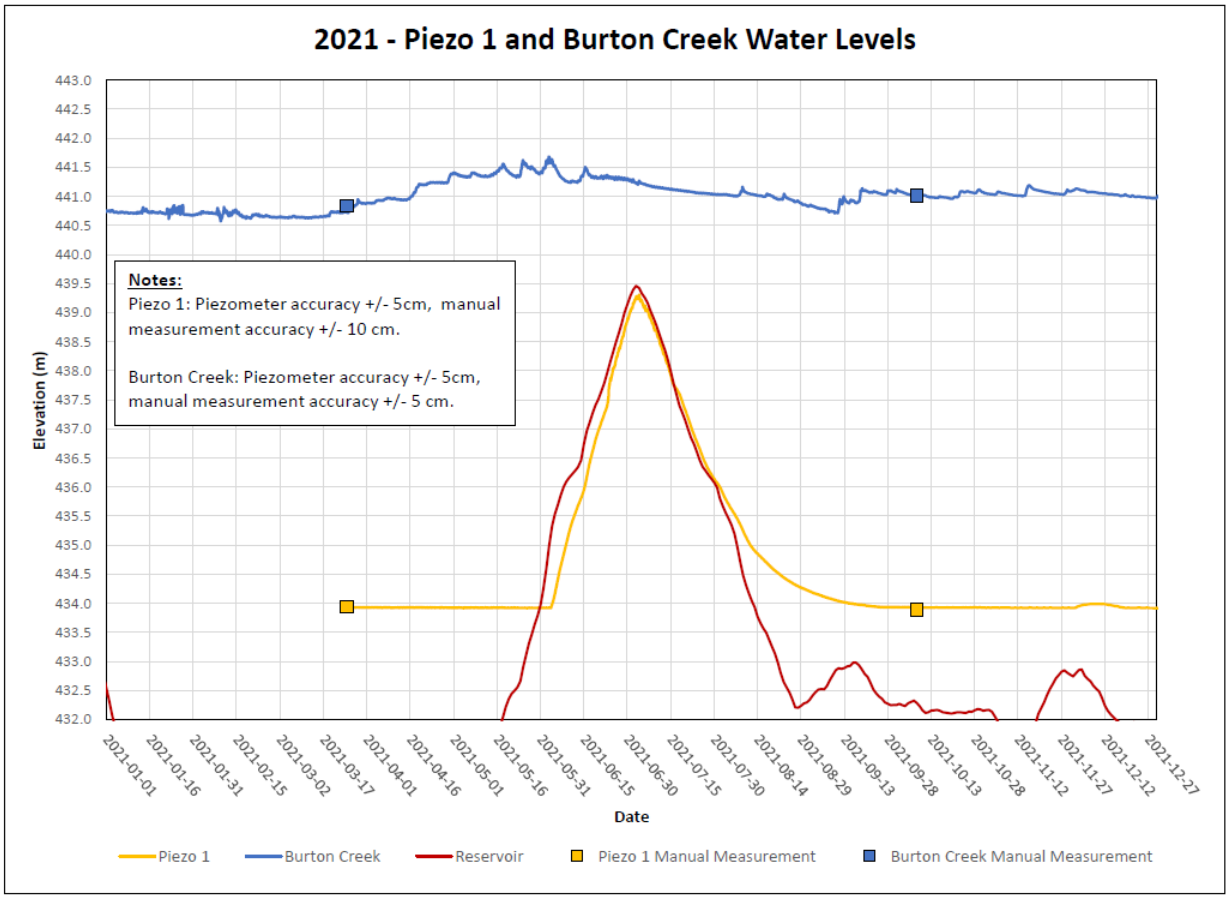

Photo 1: 2021-10-08 Burton Creek

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Enclosure 3

2022 Water Level Monitoring Results

Pond A1

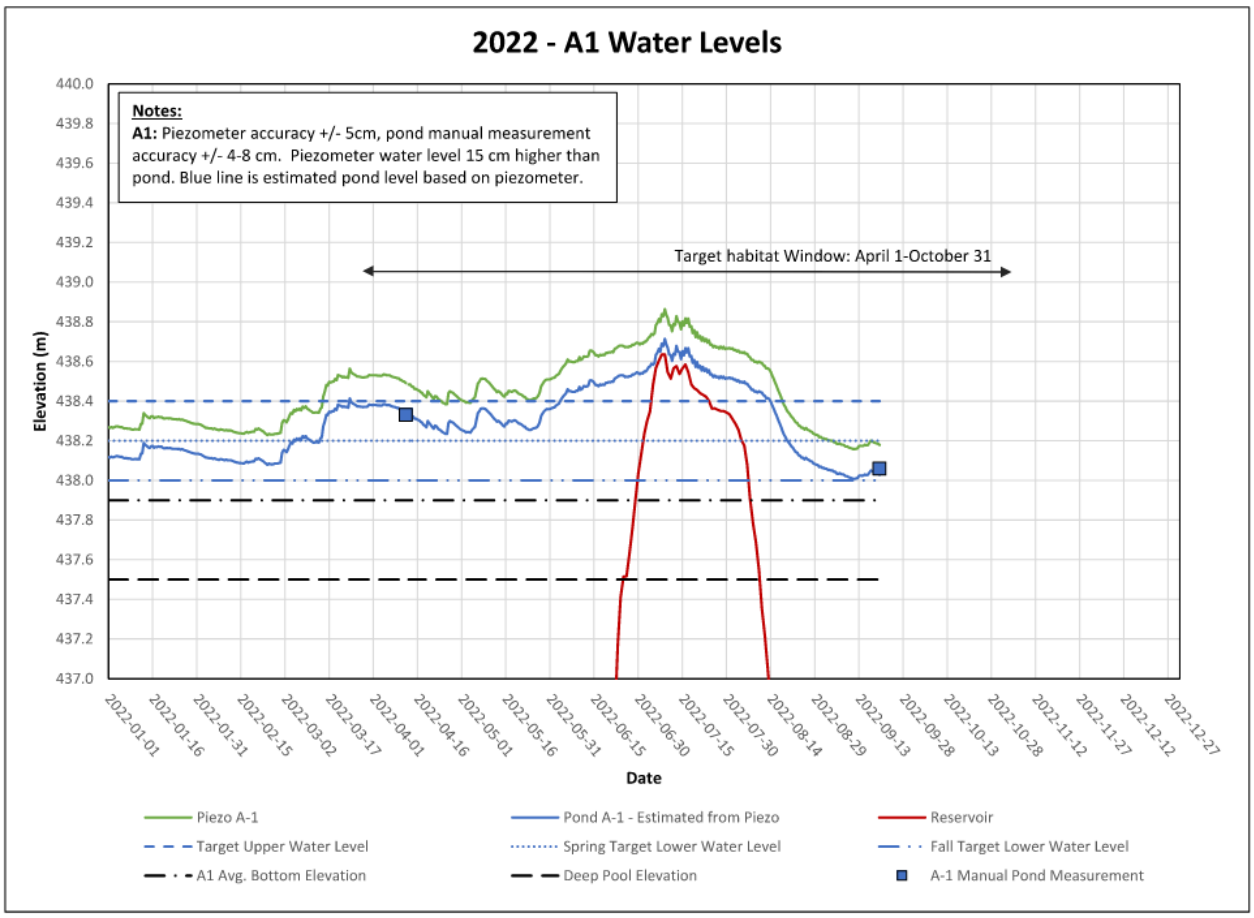

Photo 1: 2022-04-12 Pond A1

Photo 2: 2022-09-20 Pond A1

Pond A2

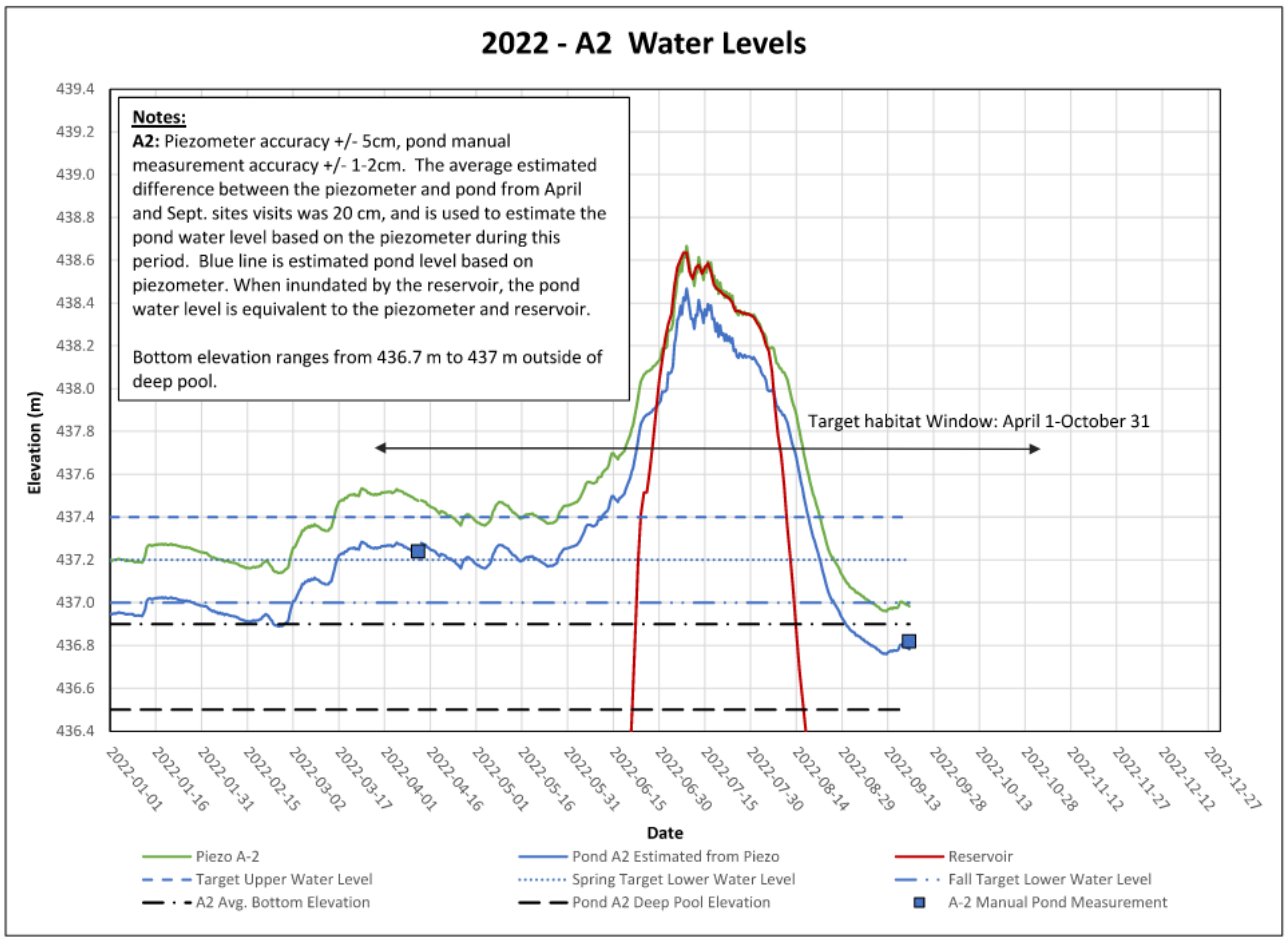

Photo 1: 2022-04-12 Pond A2

Photo 2: 2022-09-20 Pond A2

Pond A3

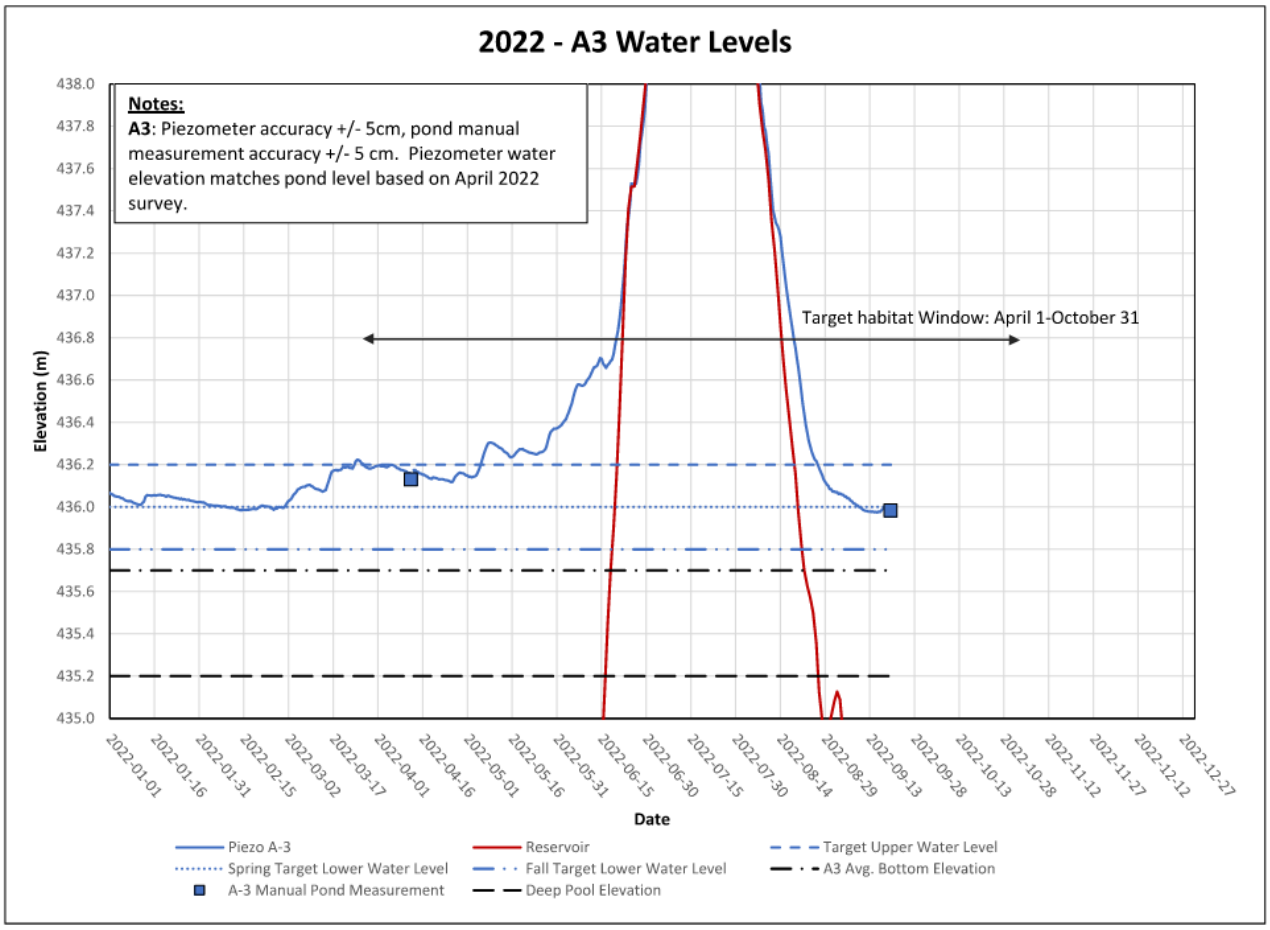

Photo 1: 2022-04-12 Pond A3

Photo 2: 2022-09-20 Pond A3

Pond A4

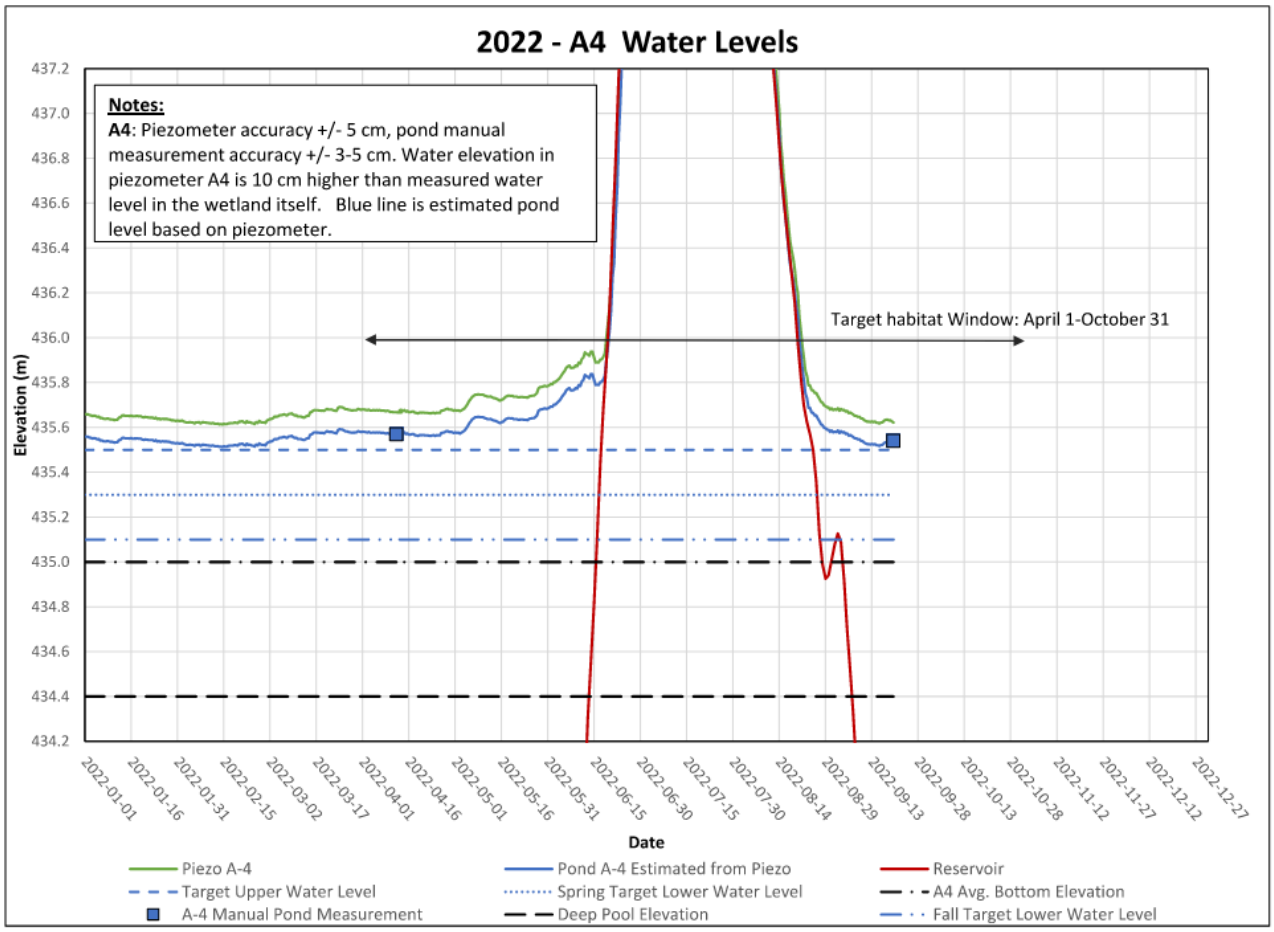

Photo 1: 2022-04-12 Pond A4

Photo 2: 2022-09-20 Pond A4

Pond A5

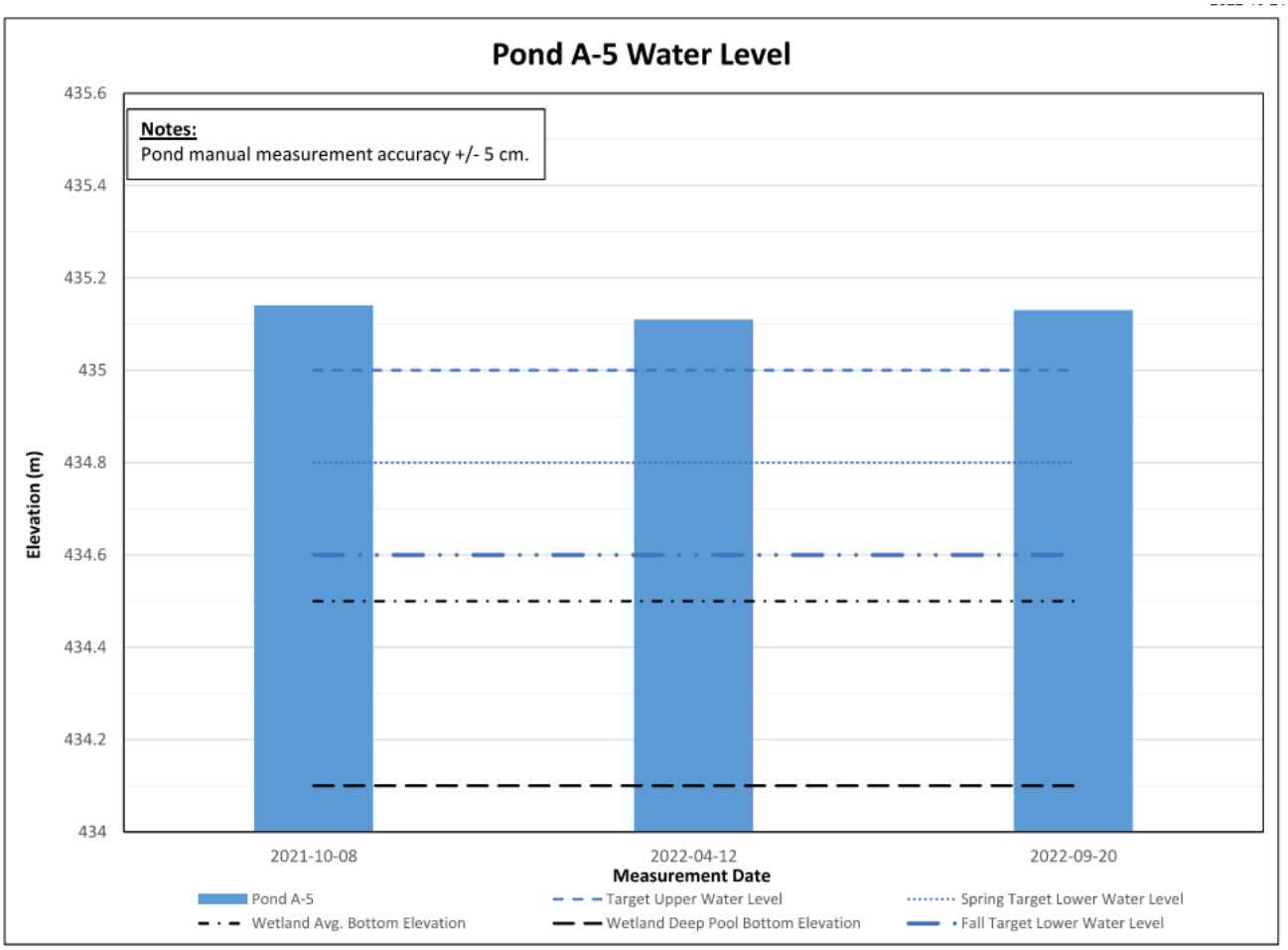

Photo 1: 2022-04-12 Pond A5

Photo 2: 2022-09-20 Pond A5

Pond A6

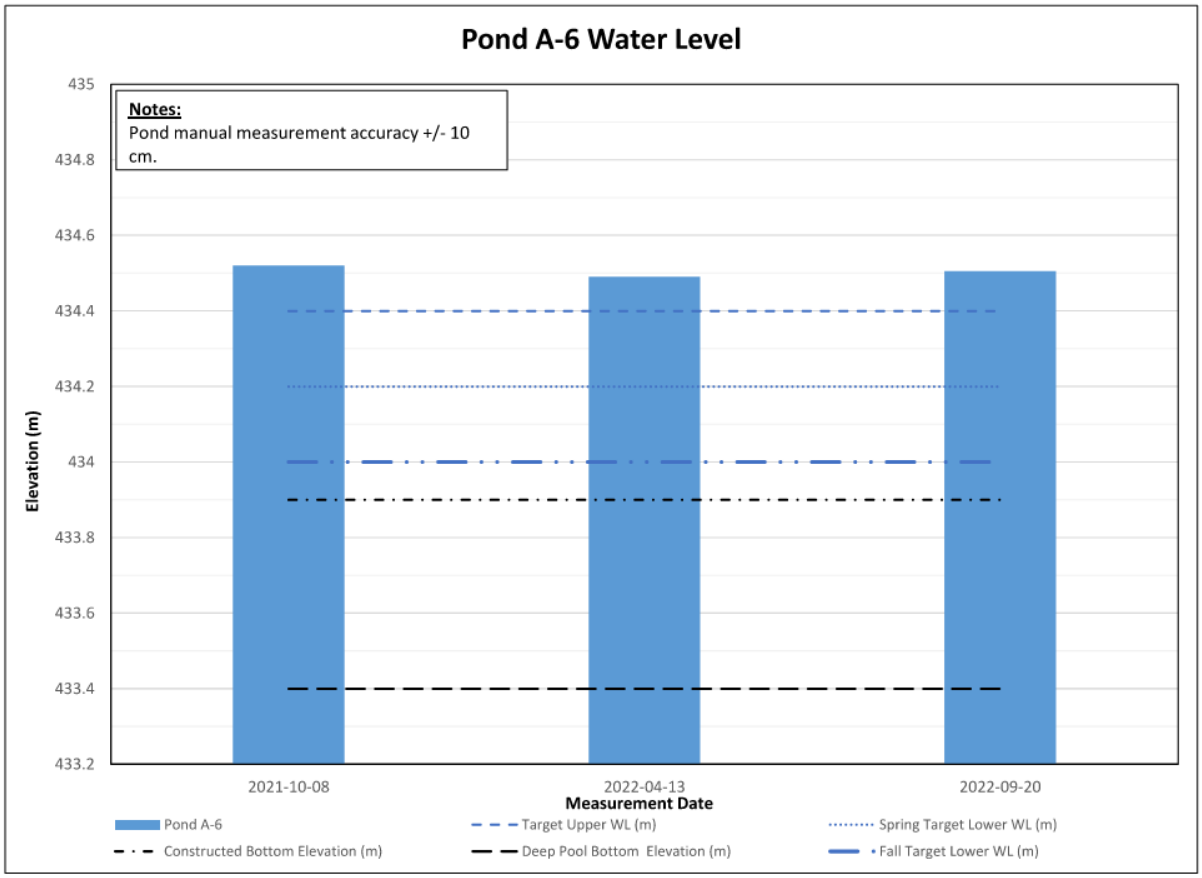

Photo 1: 2022-04-13 Pond A6

Photo 2: 2022-09-20 Pond A6

Pond B1

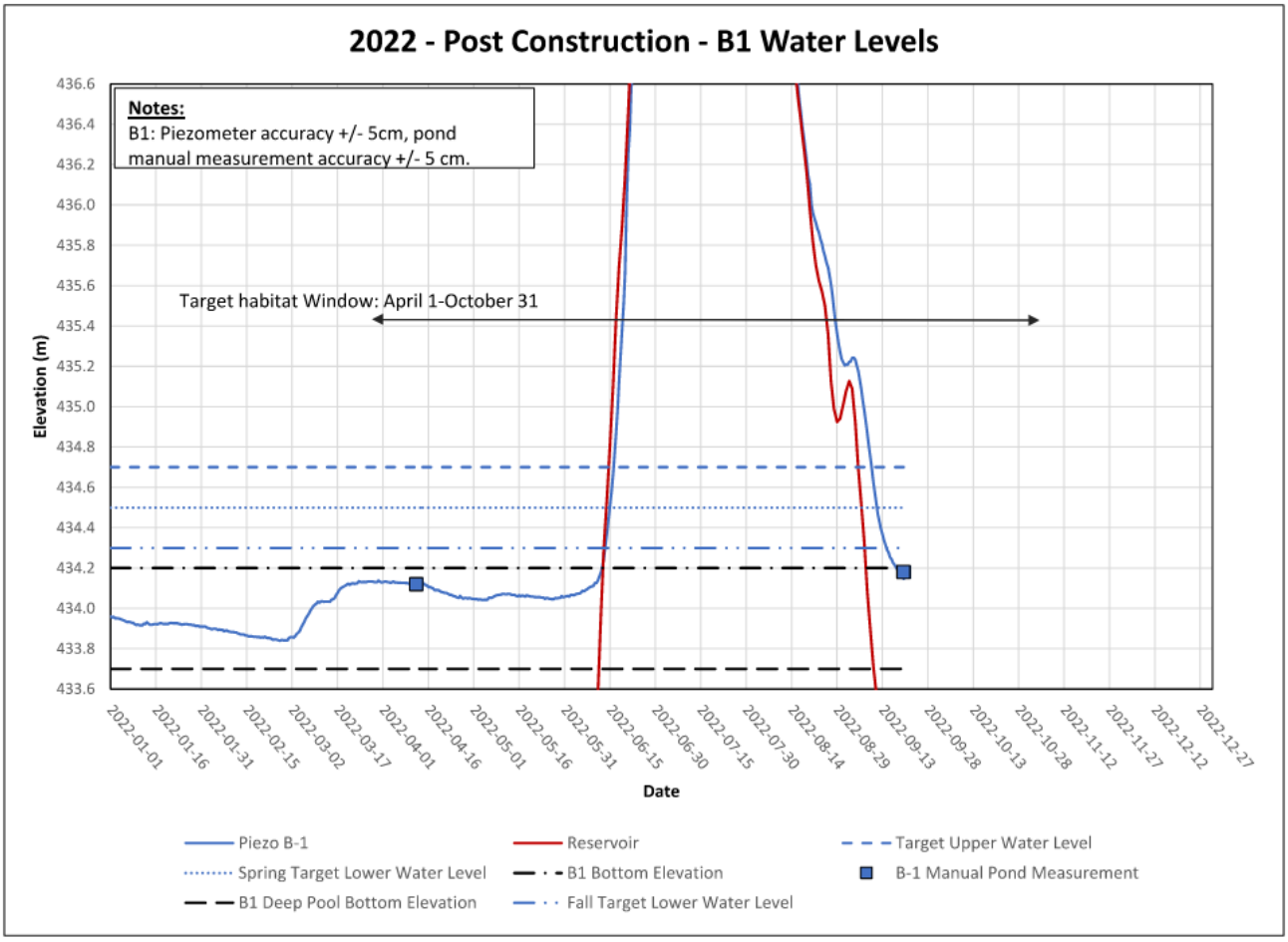

Photo 1: 2022-04-12 Pond B1

Photo 2: 2022-09-20 Pond B1

Pond B2

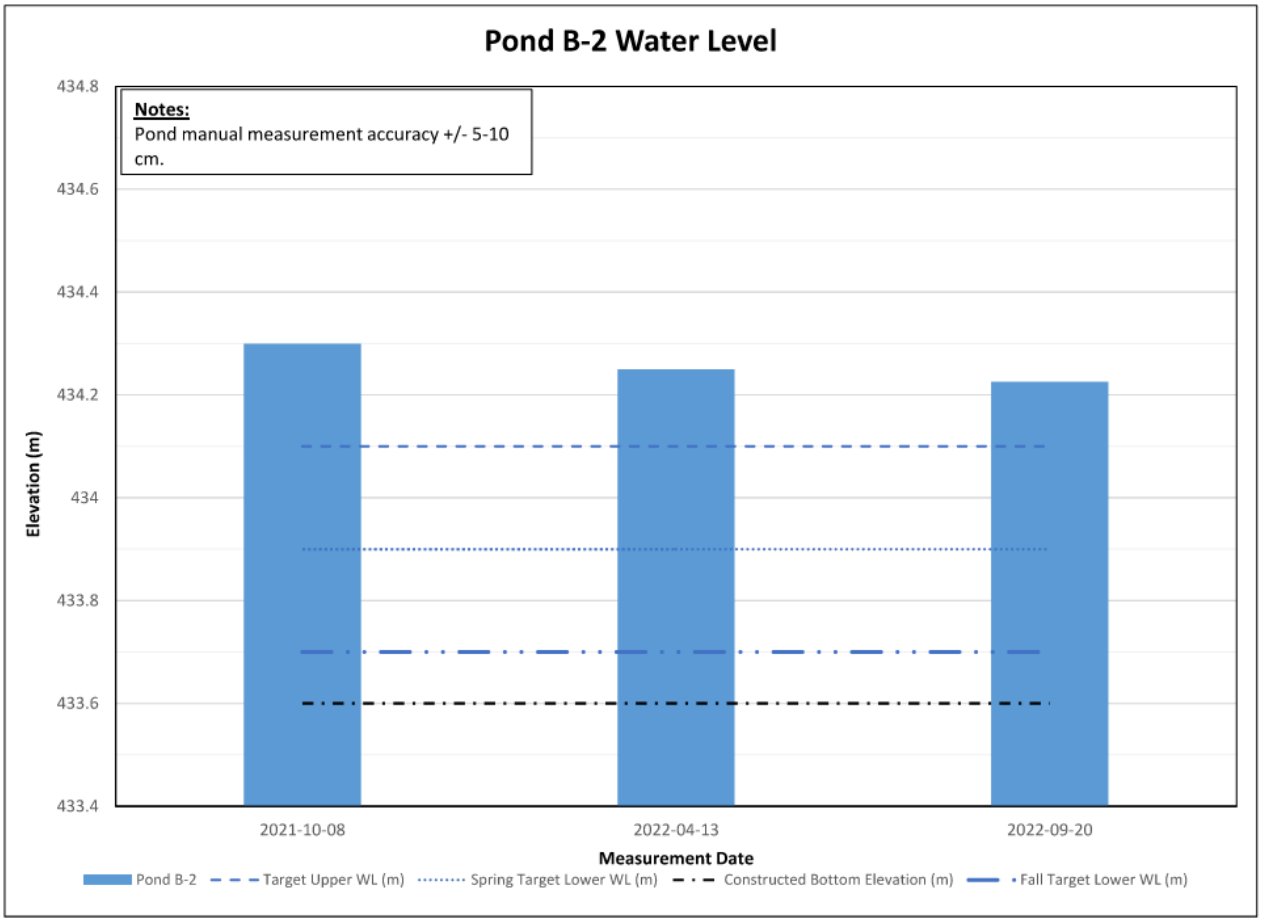

Photo 1: 2022-04-13 Pond B2

Photo 2: 2022-09-20 Pond B2

Pond D1

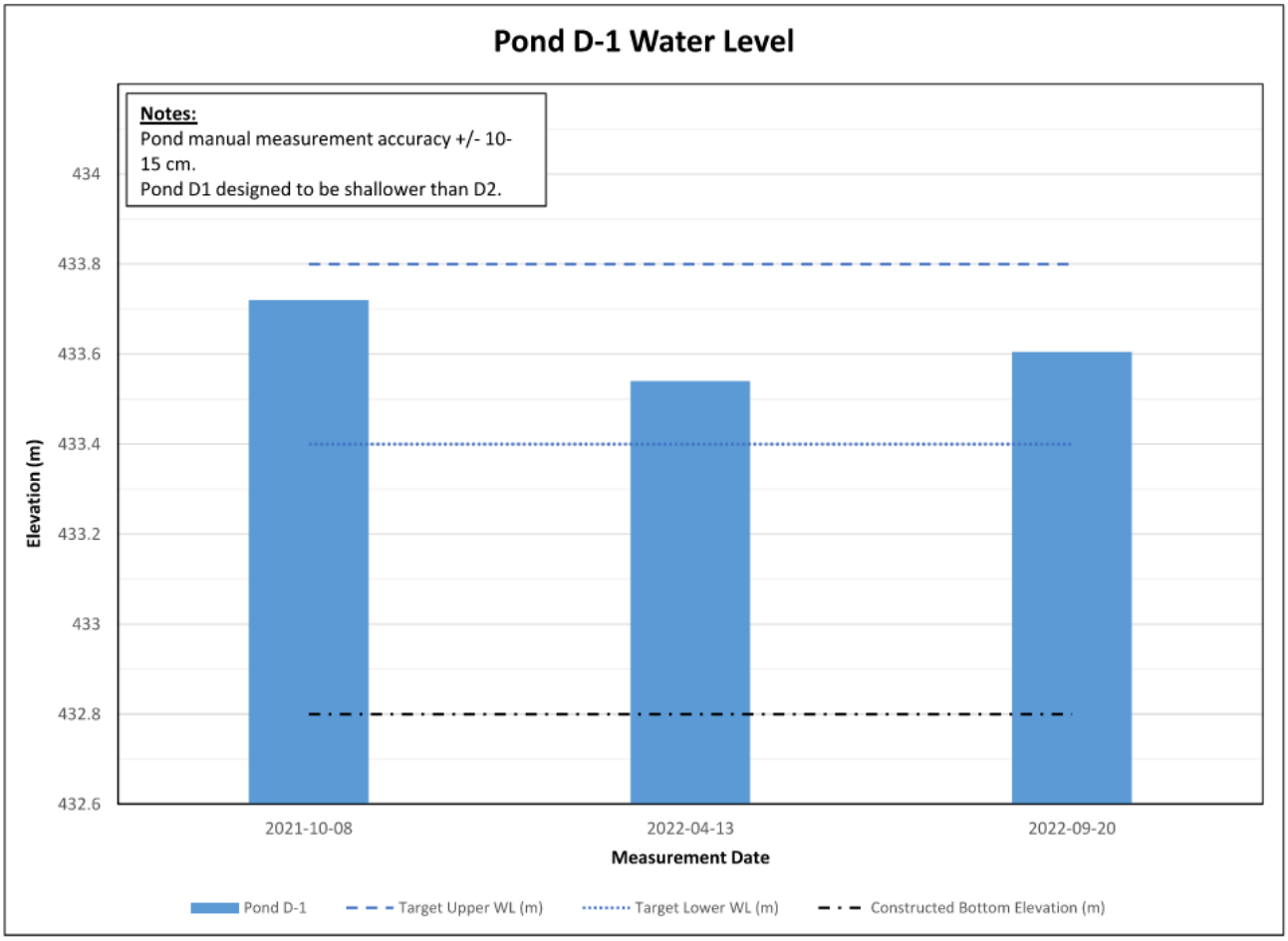

Photo 1: 2022-04-13 Pond D1

Photo 2: 2022-09-20 Pond D1

Pond D2

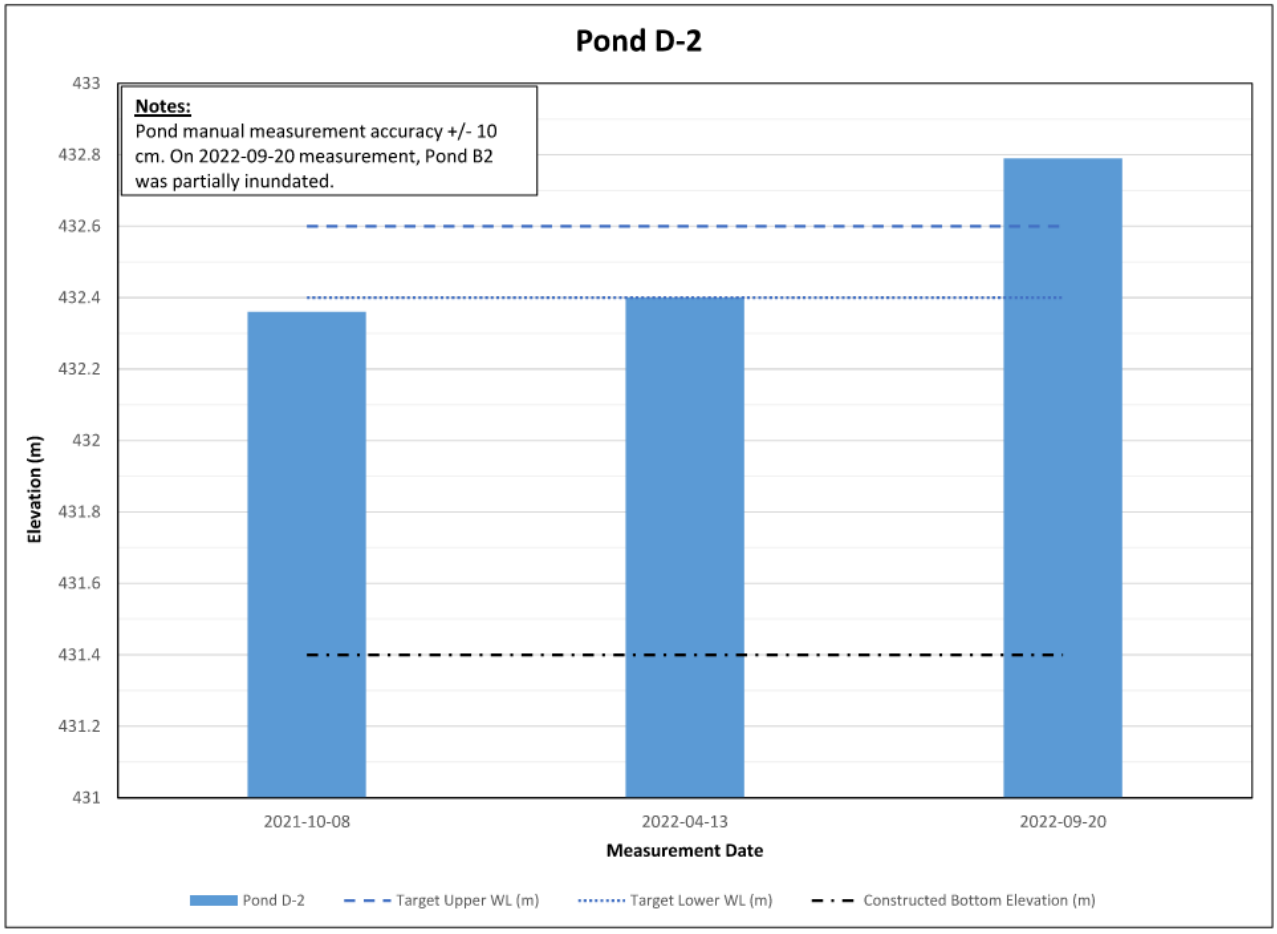

Photo 1: 2022-04-13 Pond D2

Photo 2: 2022-09-20 Pond D2

Burton Creek

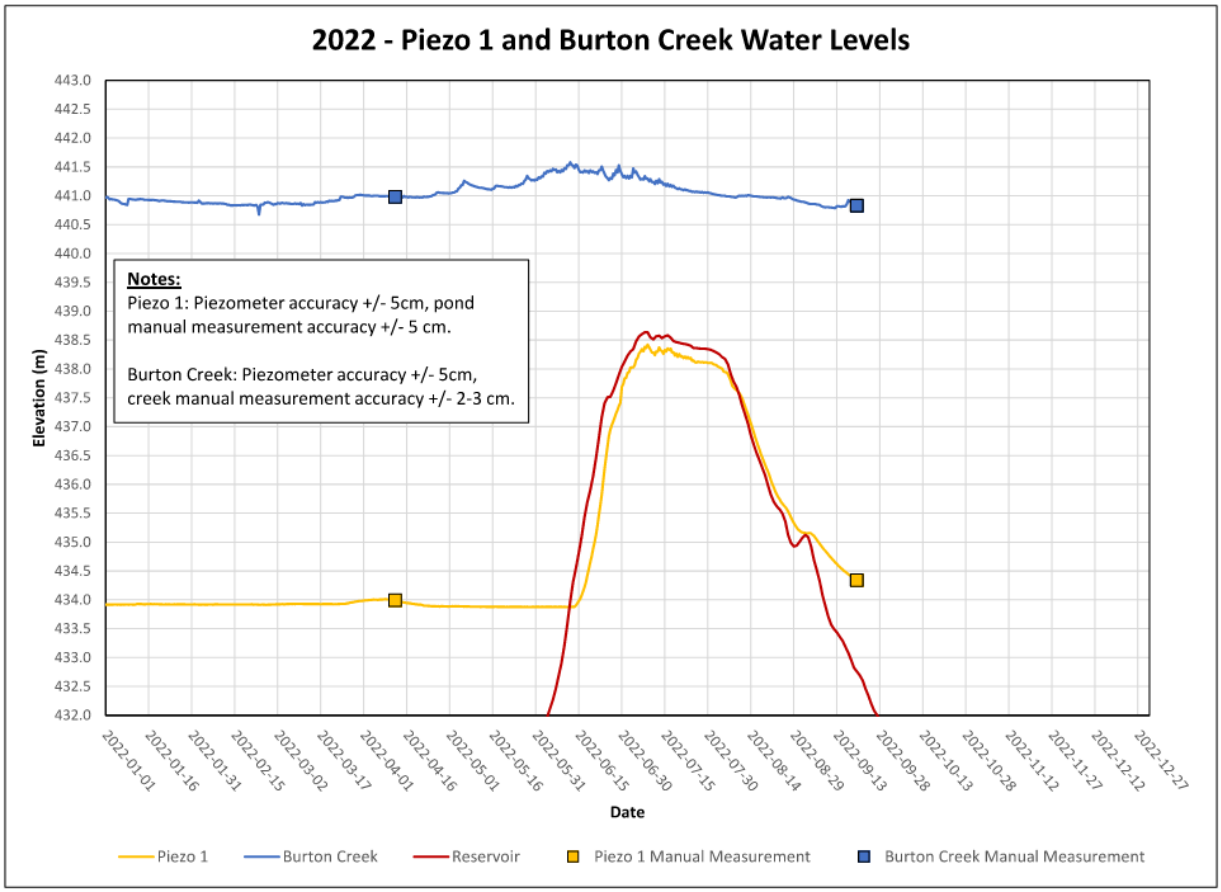

Photo 1: 2022-04-13 Burton Creek

Photo 2: 2022-09-20 Burton Creek

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Enclosure 4

2023 Water Level Monitoring Results

Pond A1

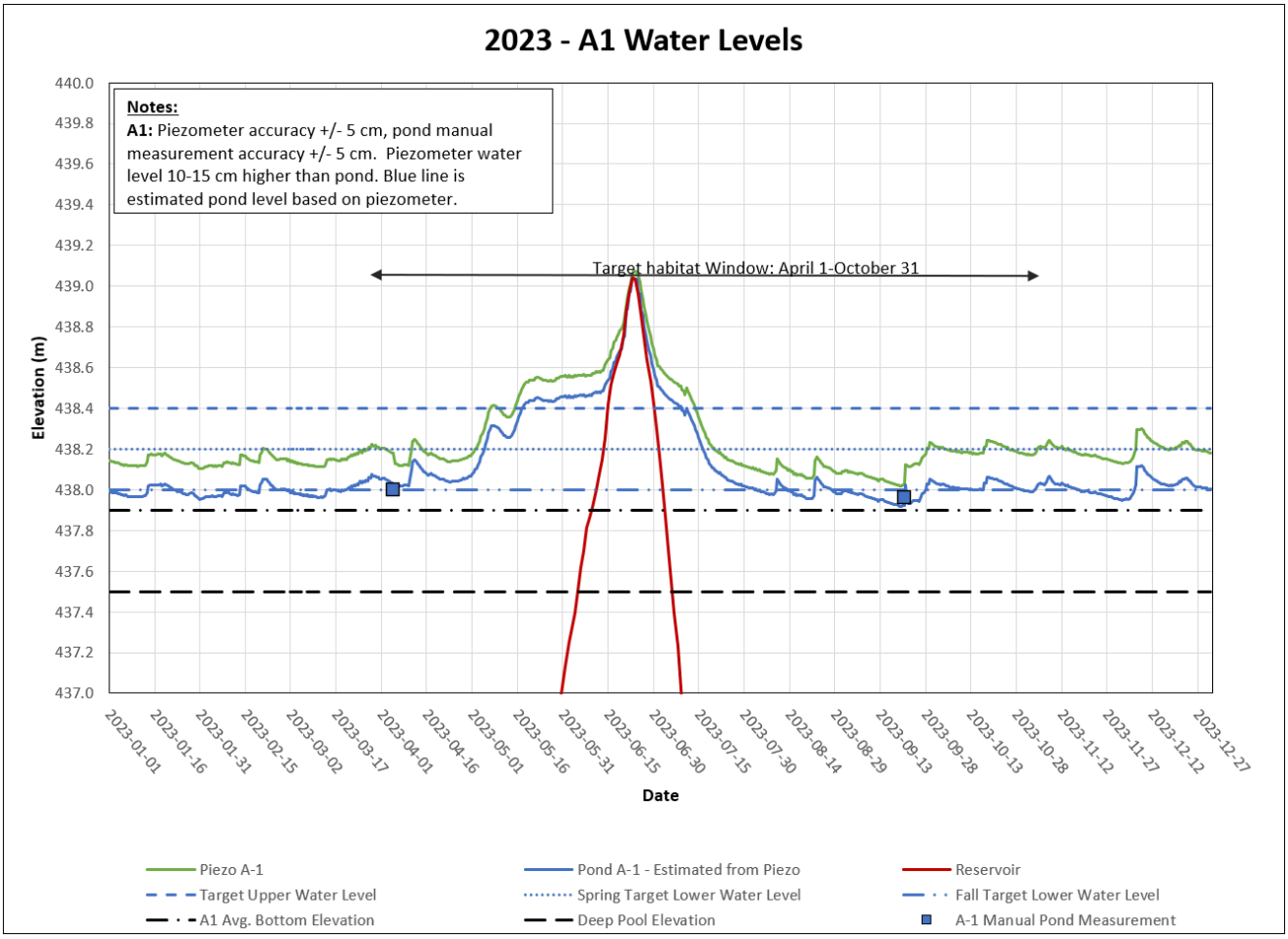

Photo 1: 2023-04-05 Pond A1

Photo 2: 2023-09-21 Pond A1

Pond A2

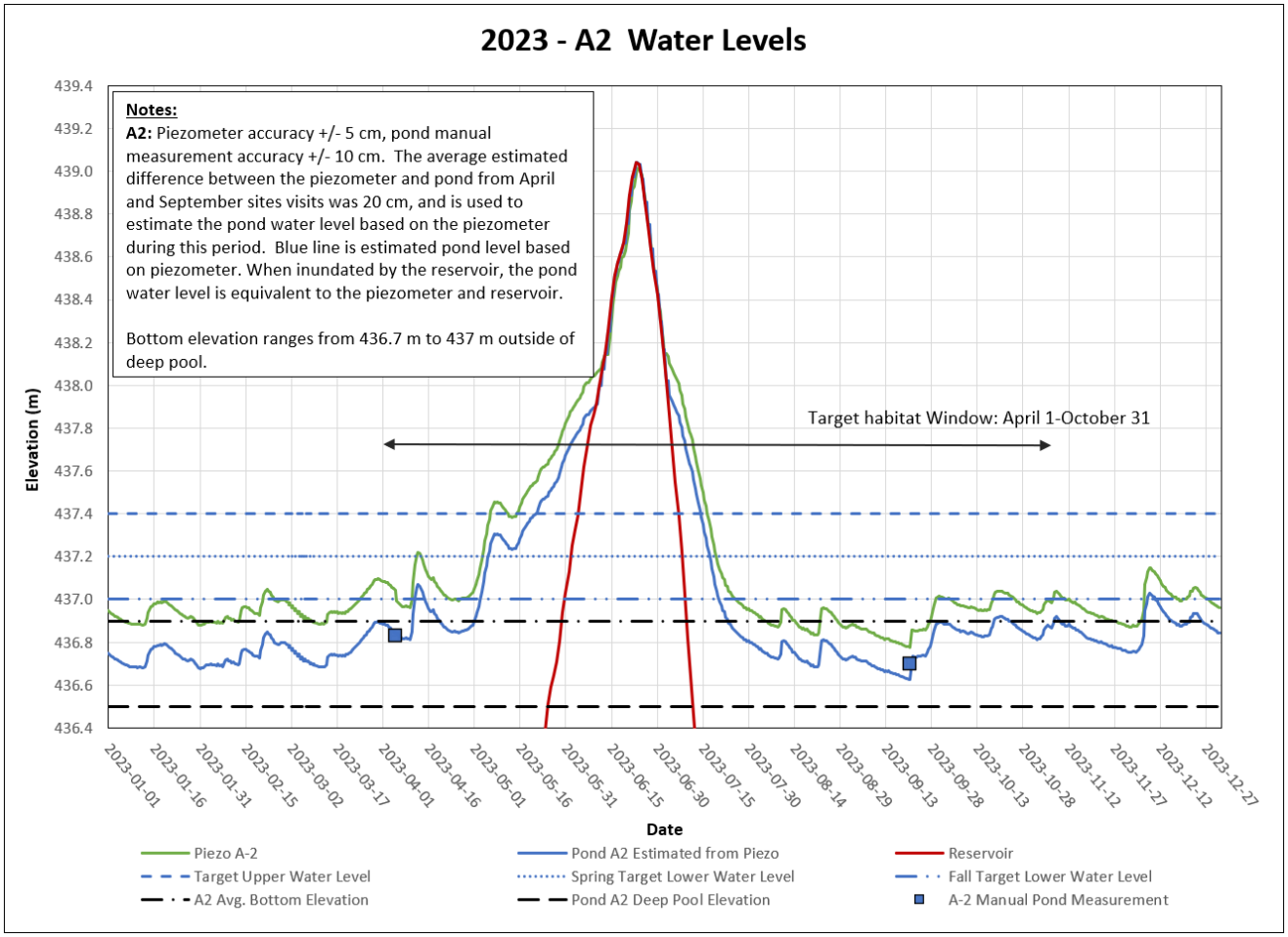

Photo 1: 2023-04-05 Pond A2

Photo 2: 2023-09-21 Pond A2

Pond A3

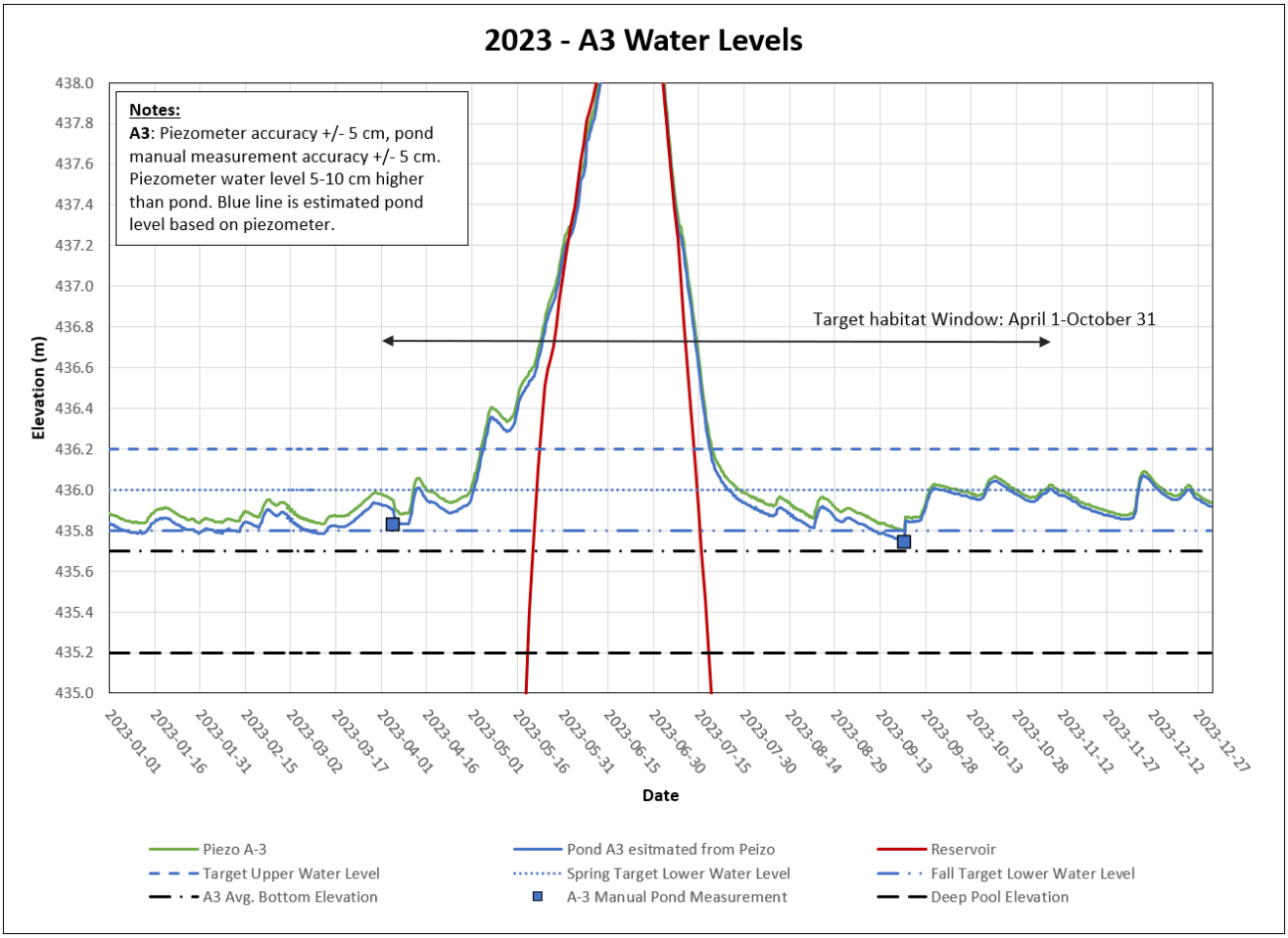

Photo 1: 2023-04-05 Pond A3

Photo 2: 2023-09-21 Pond A3

Pond A4

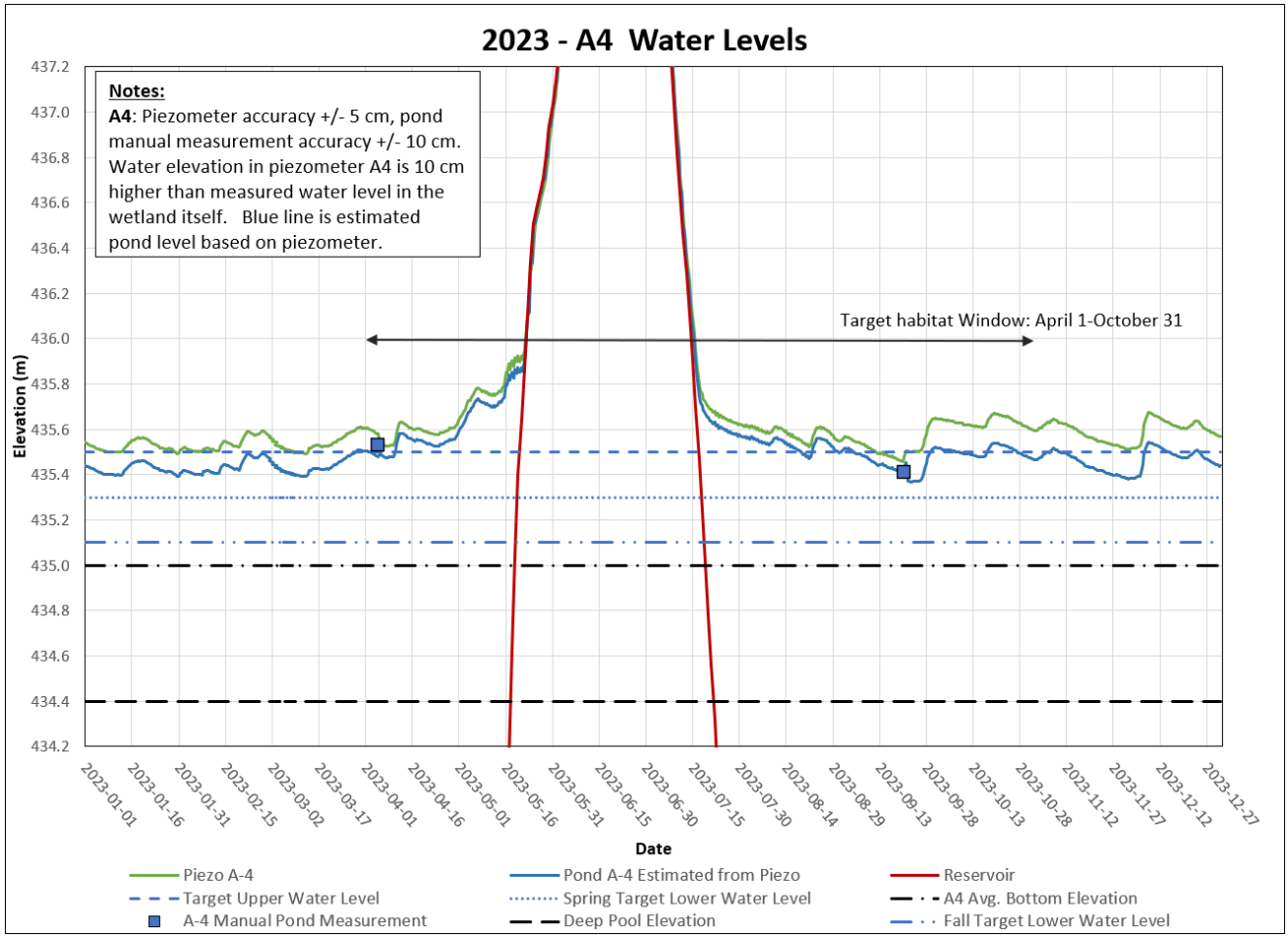

Photo 1: 2023-04-05 Pond A4

Photo 2: 2023-09-21 Pond A4

Pond A5

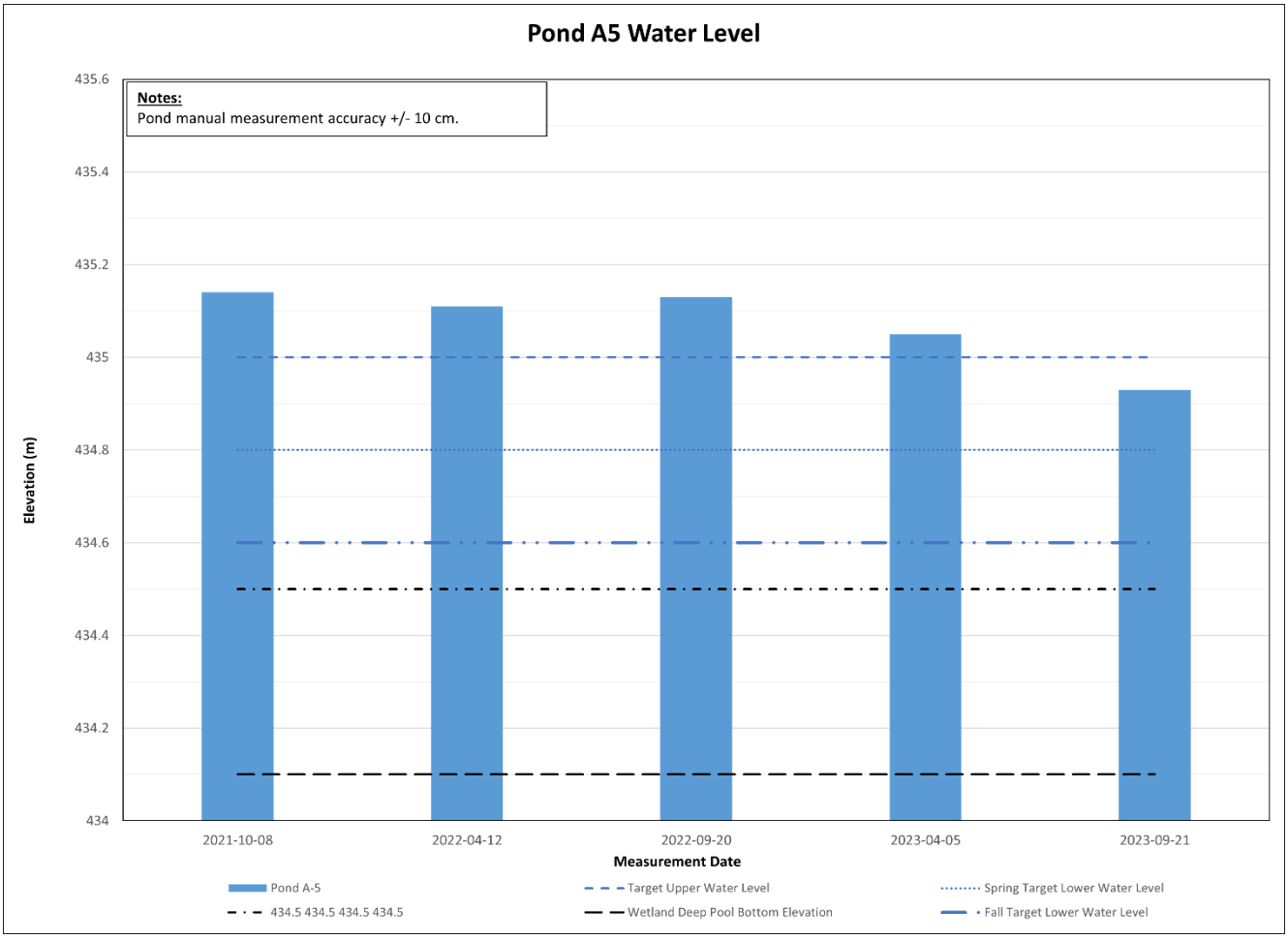

Photo 1: 2023-04-05 Pond A5

Photo 2: 2023-09-21 Pond A5

Pond A6

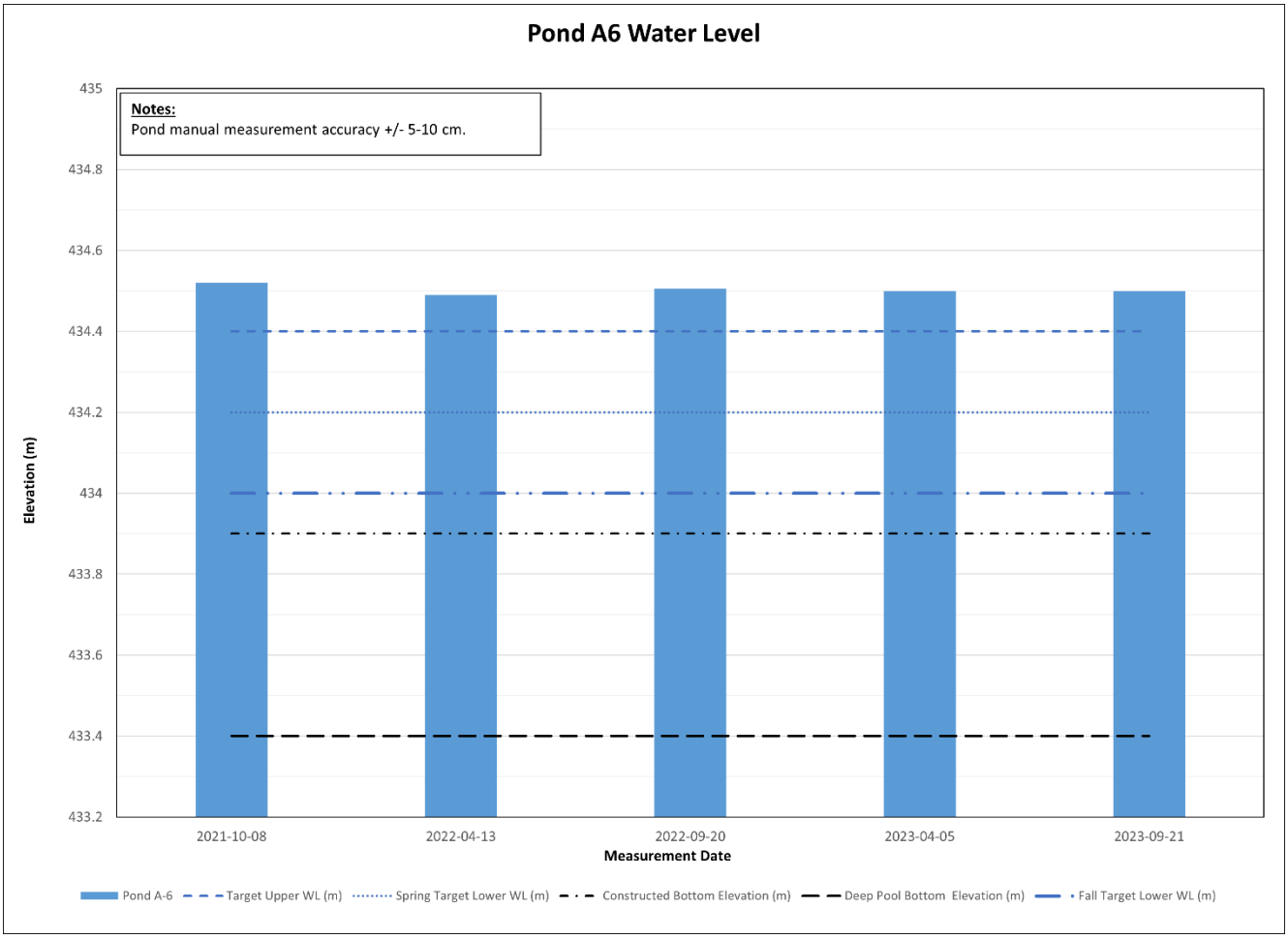

Photo 1: 2023-04-05 Pond A6

Photo 2: 2023-09-21 Pond A6

Pond B1

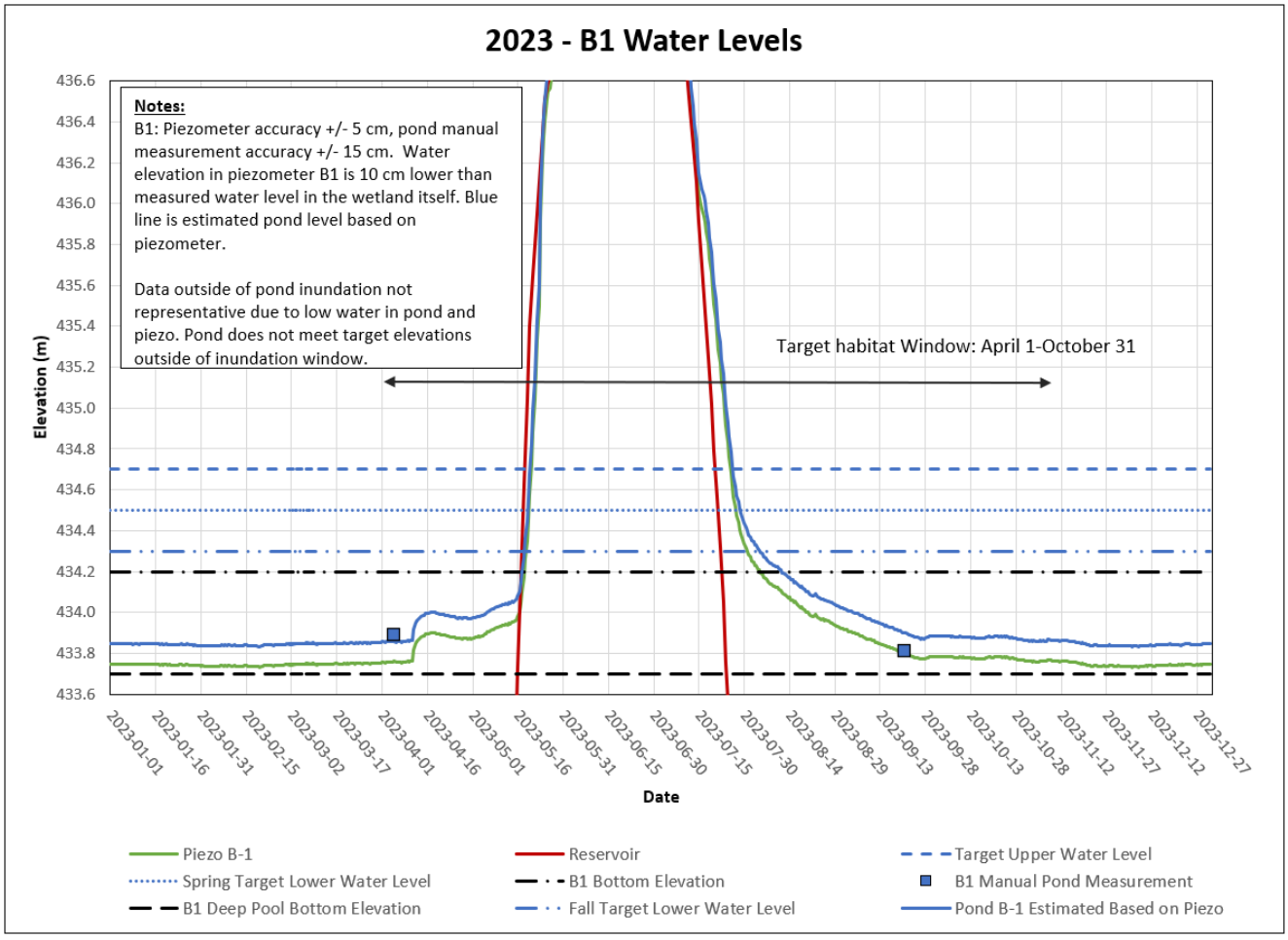

Photo 1: 2023-04-05 Pond B1

Photo 2: 2023-09-21 Pond B1

Pond B2

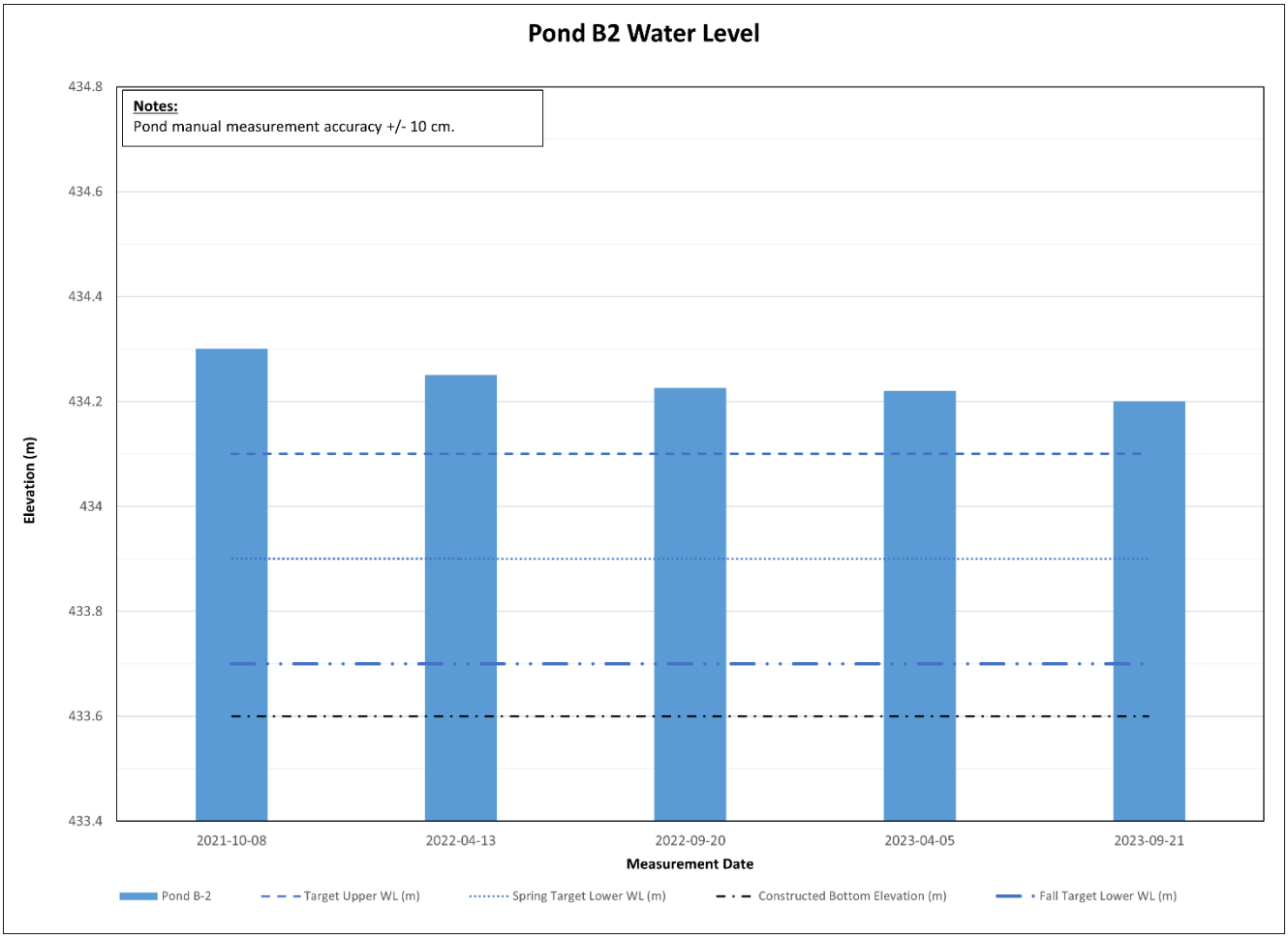

Photo 1: 2023-04-05 Pond B2

Photo 2: 2023-09-21 Pond B2

Pond D1

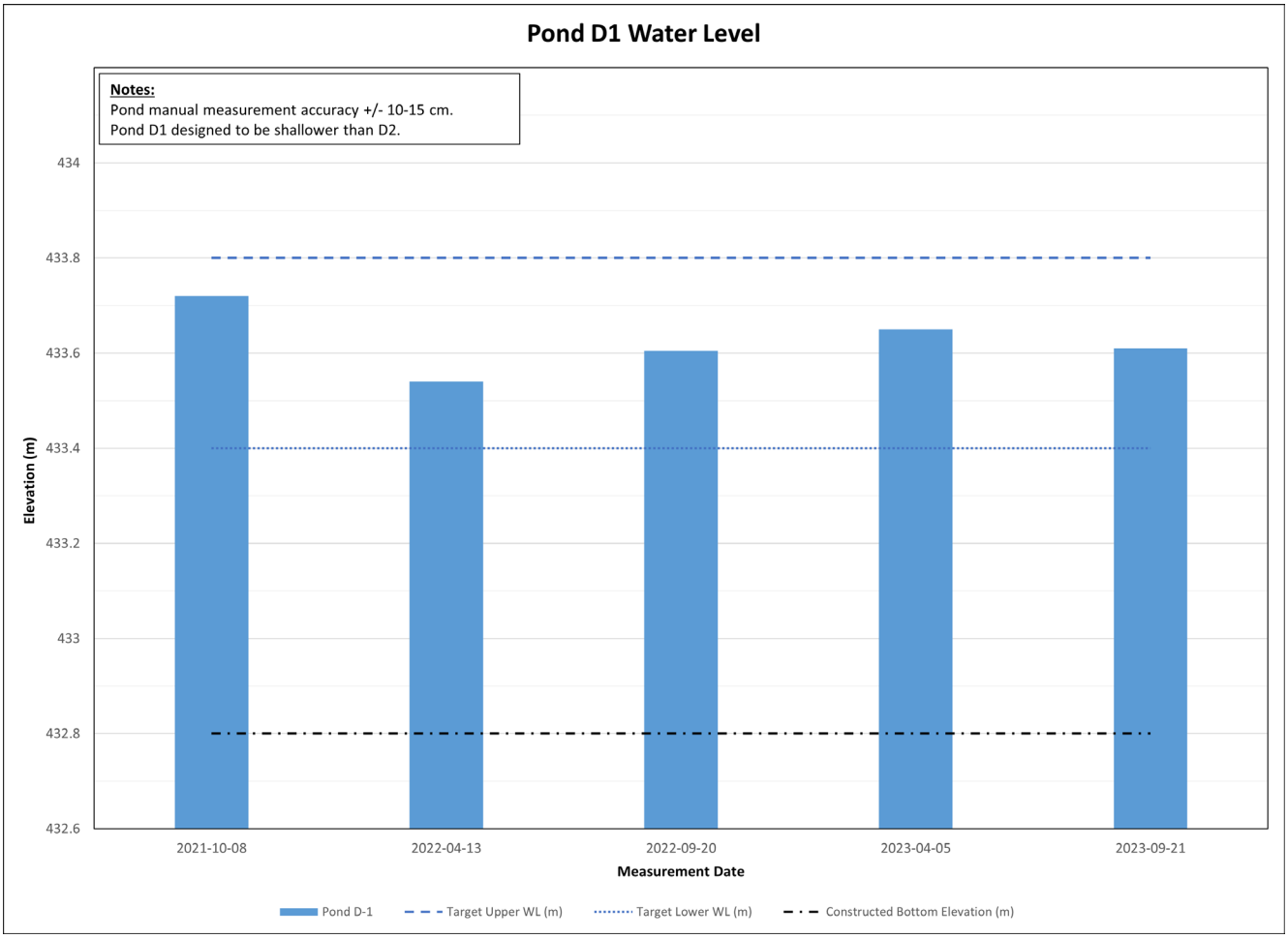

Photo 1: 2023-04-05 Pond D1

Photo 2: 2023-09-21 Pond D1

Pond D2

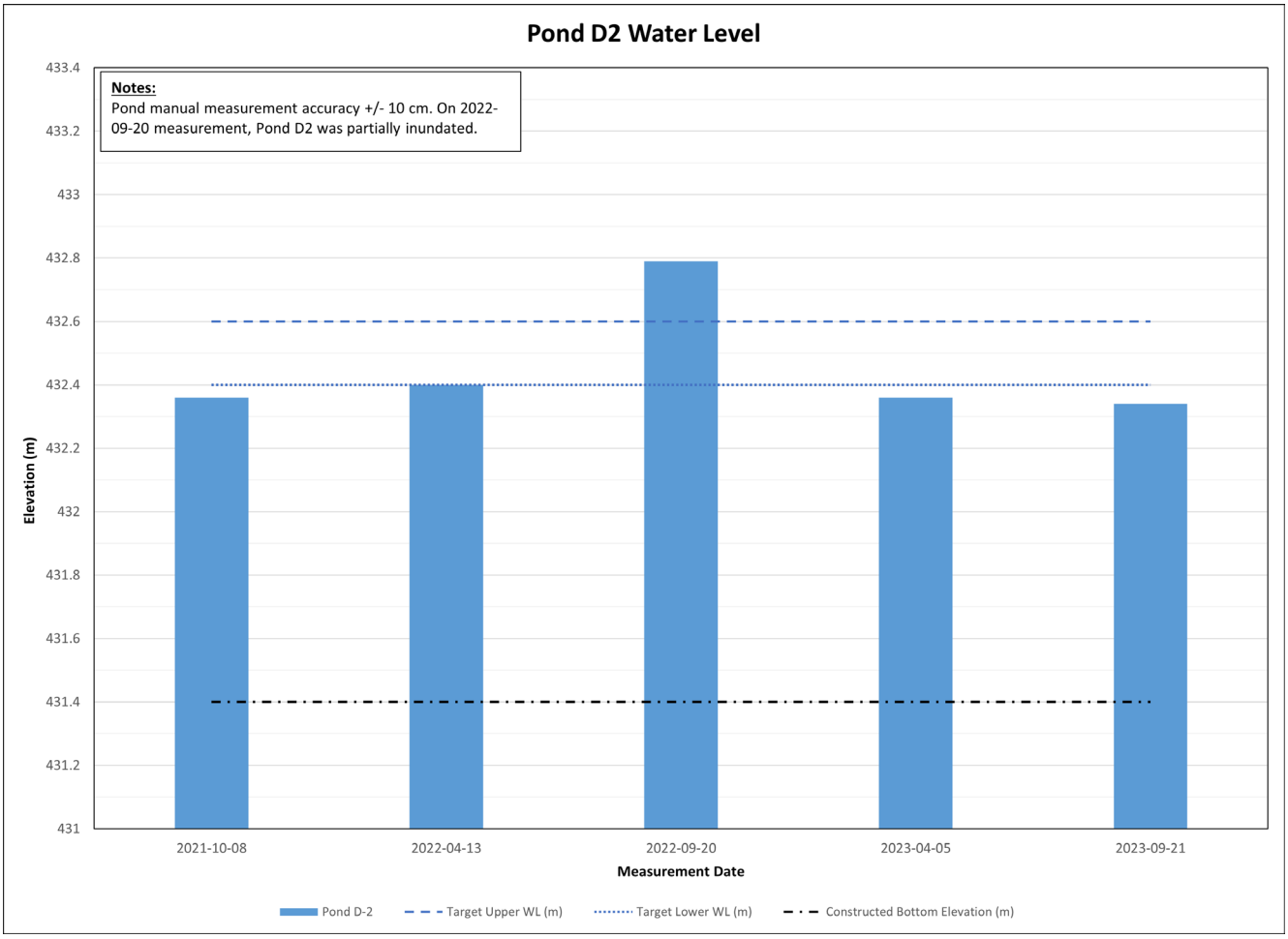

Photo 1: 2023-04-05 Pond D2

Photo 2: 2023-09-21 Pond D2

Burton Creek

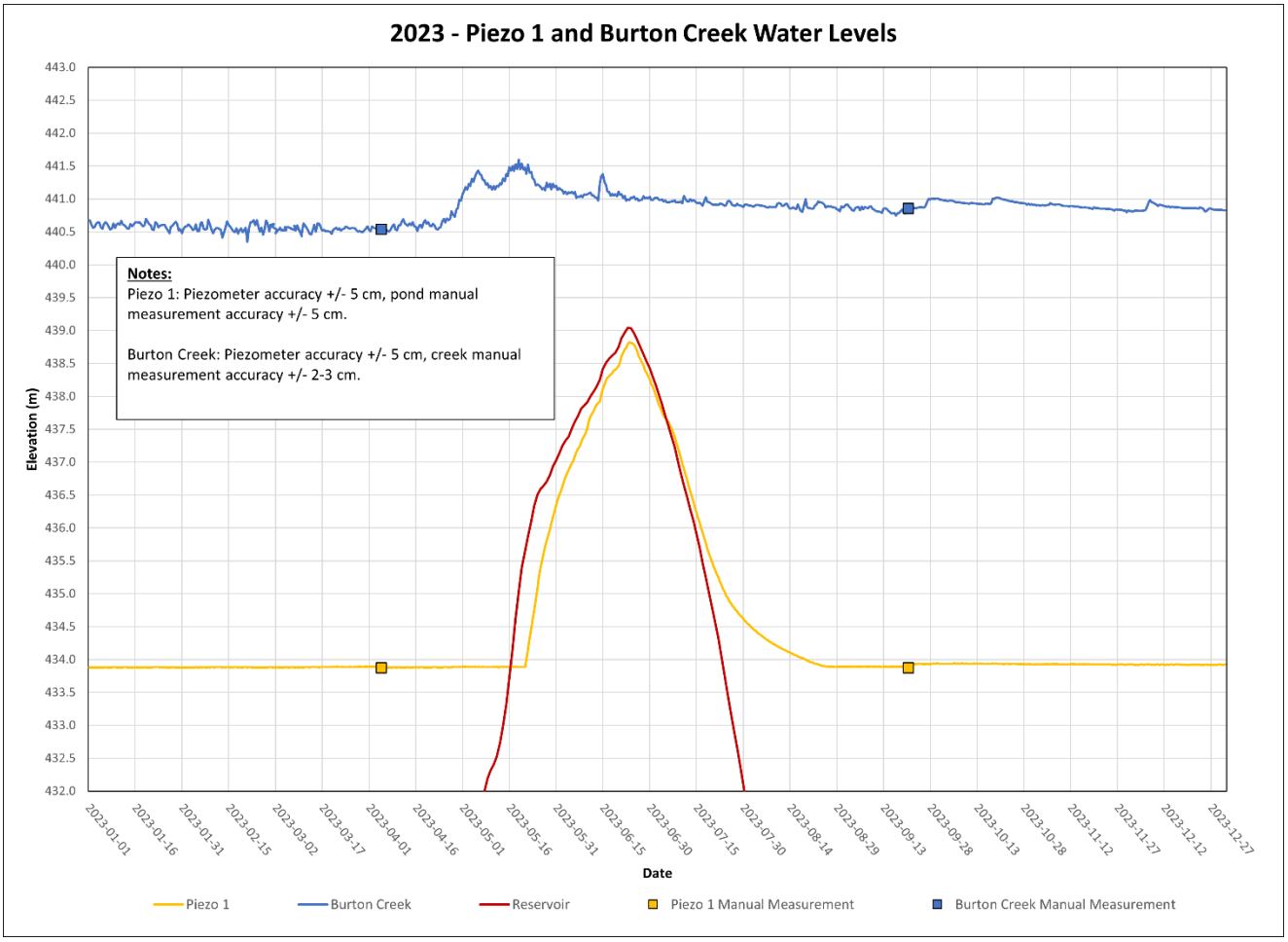

Photo 1: 2023-09-21 Burton Creek

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Enclosure 5

2024 Water Level Monitoring Results

Pond A1

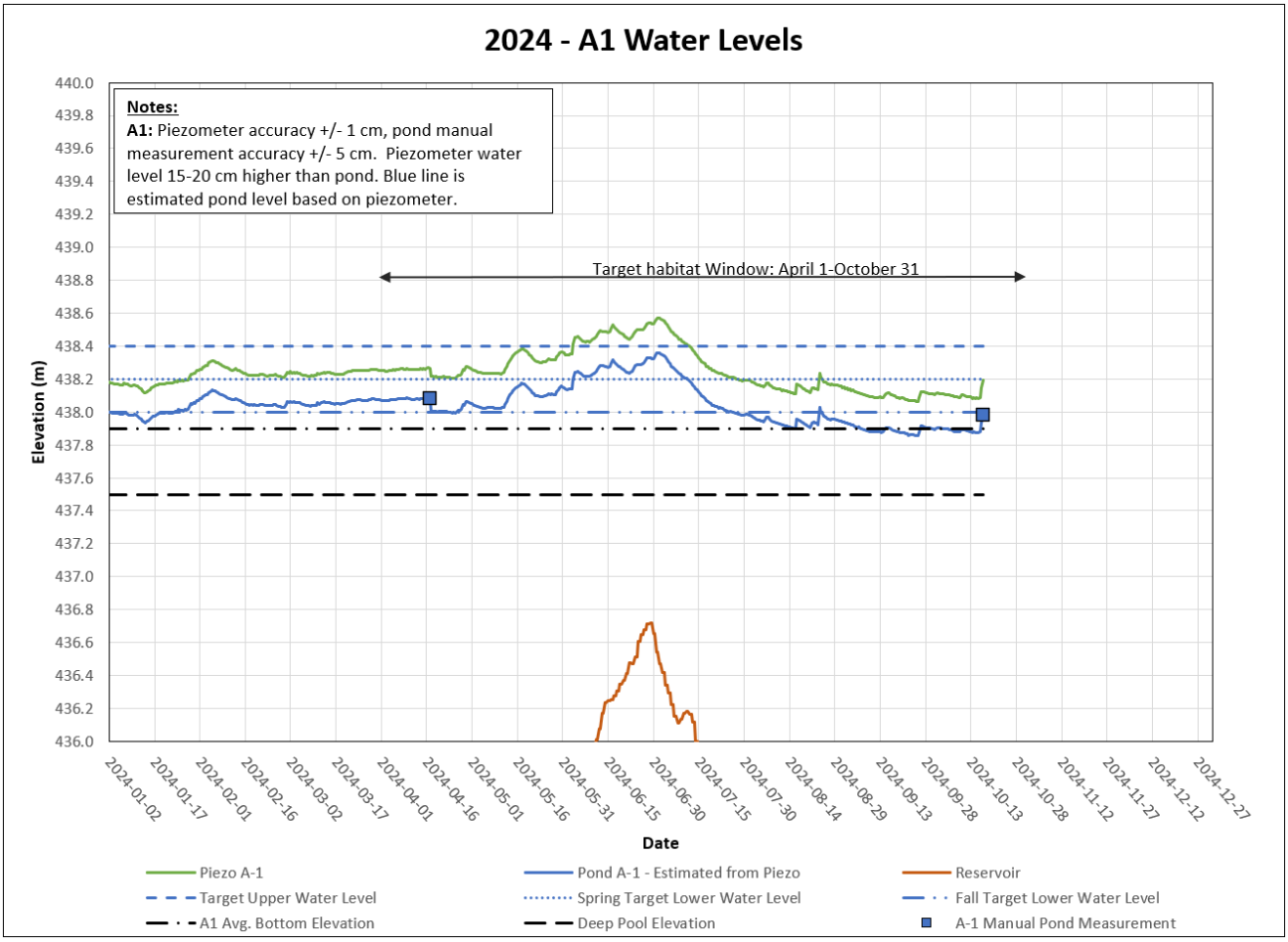

Photo 1: 2024-04-17 Pond A1

Photo 2: 2024-10-17 Pond A1

Pond A2

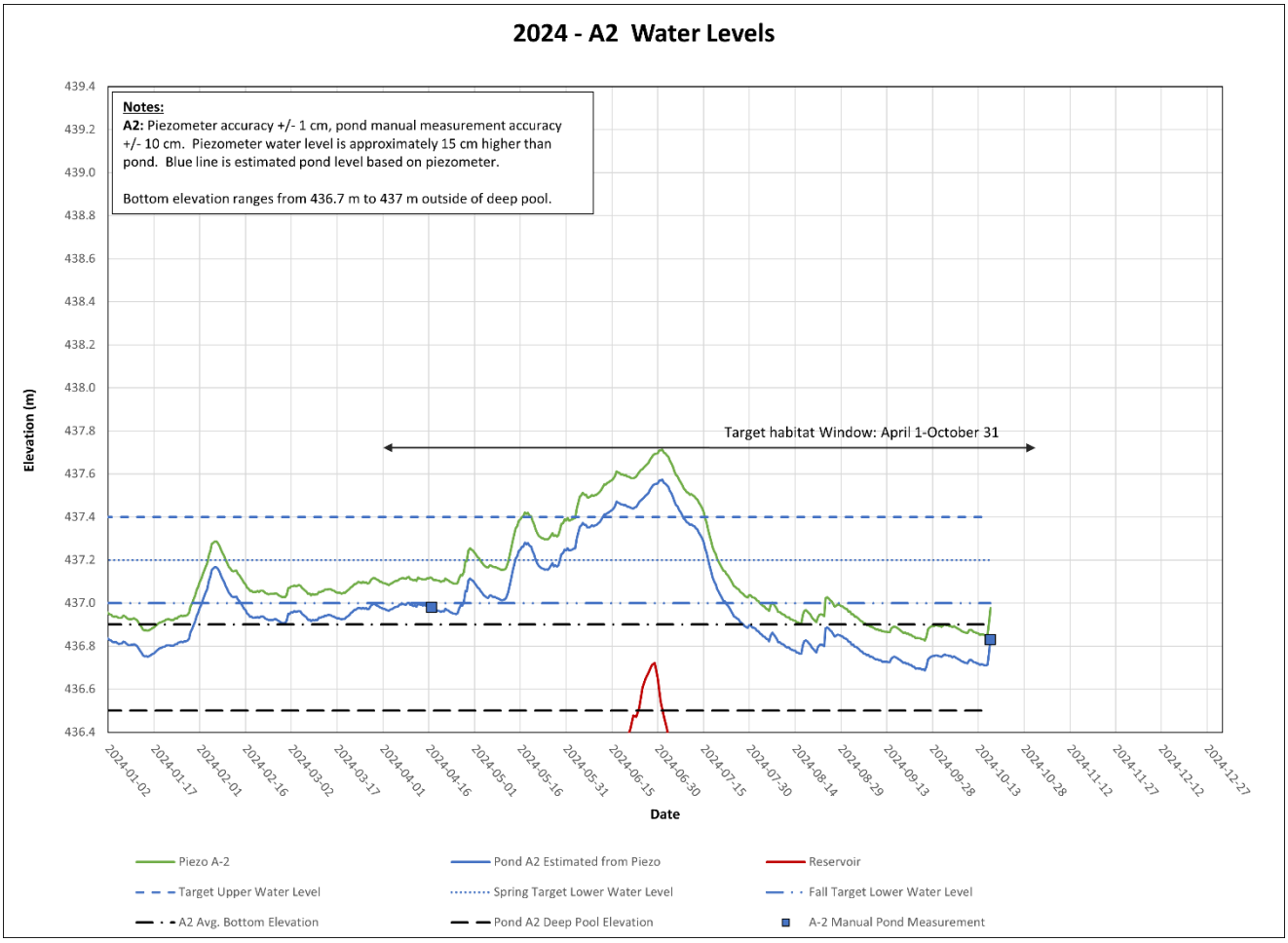

Photo 1: 2024-04-17 Pond A2

Photo 2: 2024-10-17 Pond A2

Pond A3

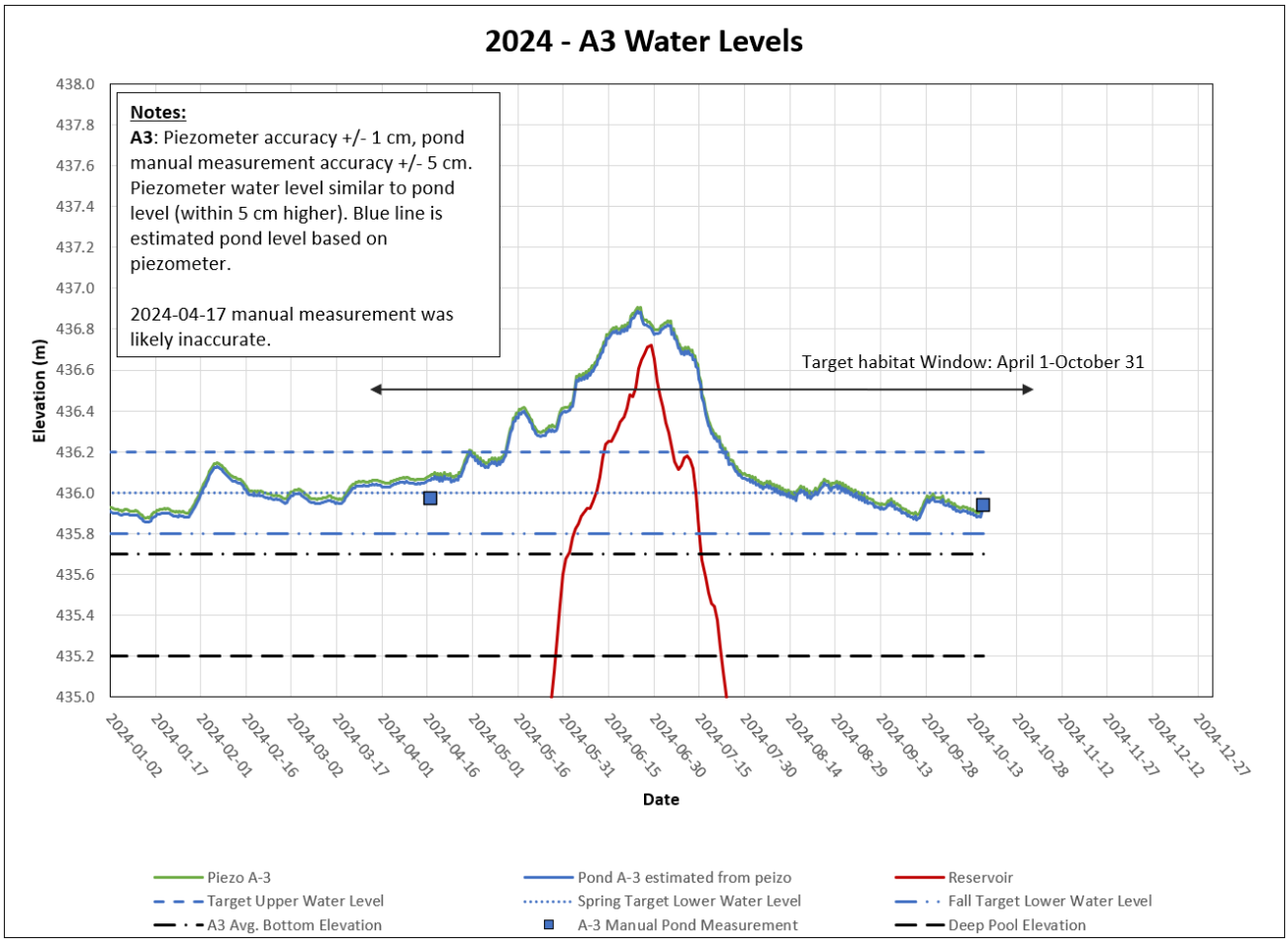

Photo 1: 2024-04-17 Pond A3

Photo 2: 2024-10-17 Pond A3

Pond A4

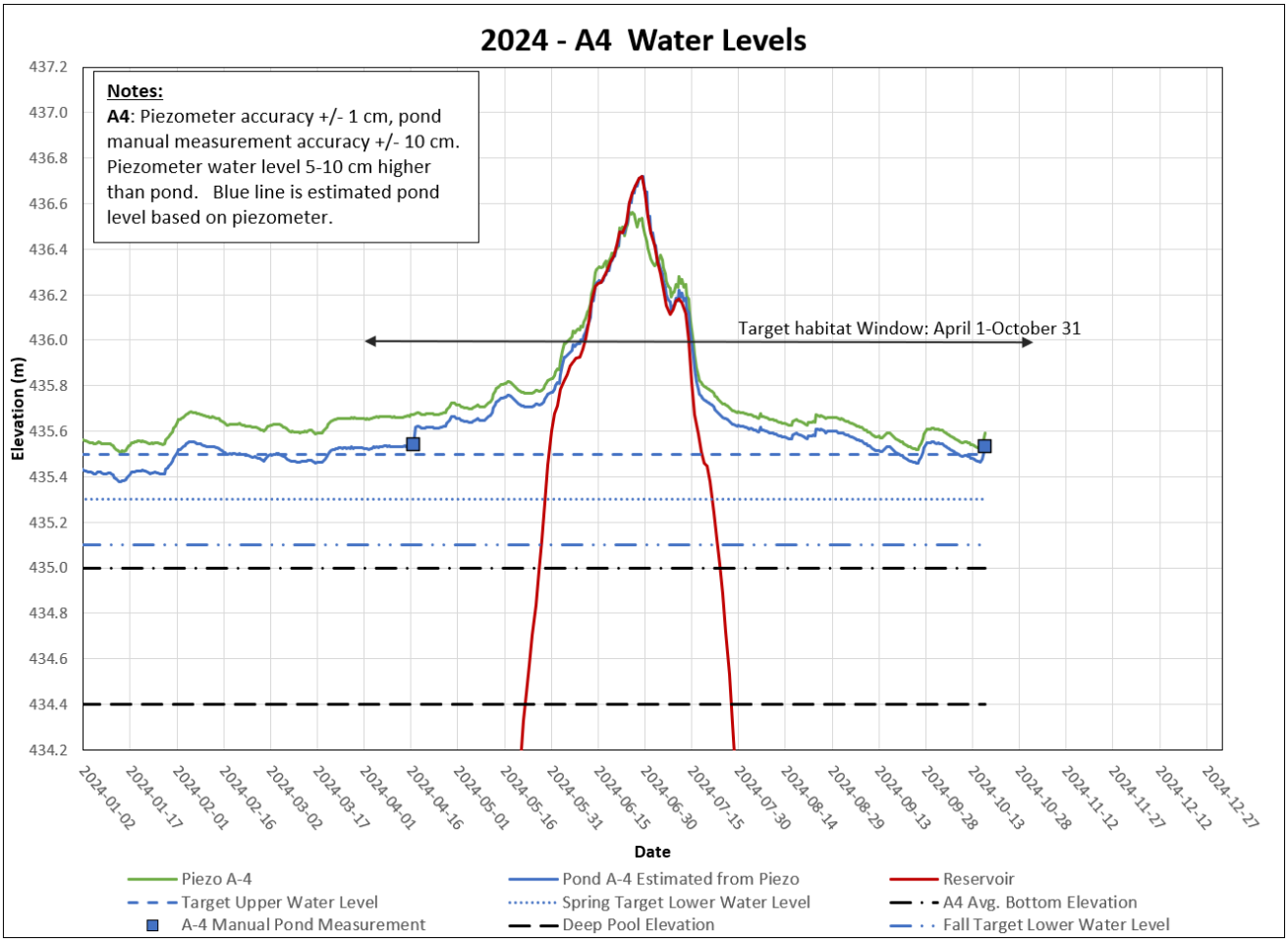

Photo 1: 2024-04-17 Pond A4

Photo 2: 2024-10-17 Pond A4

Pond A5

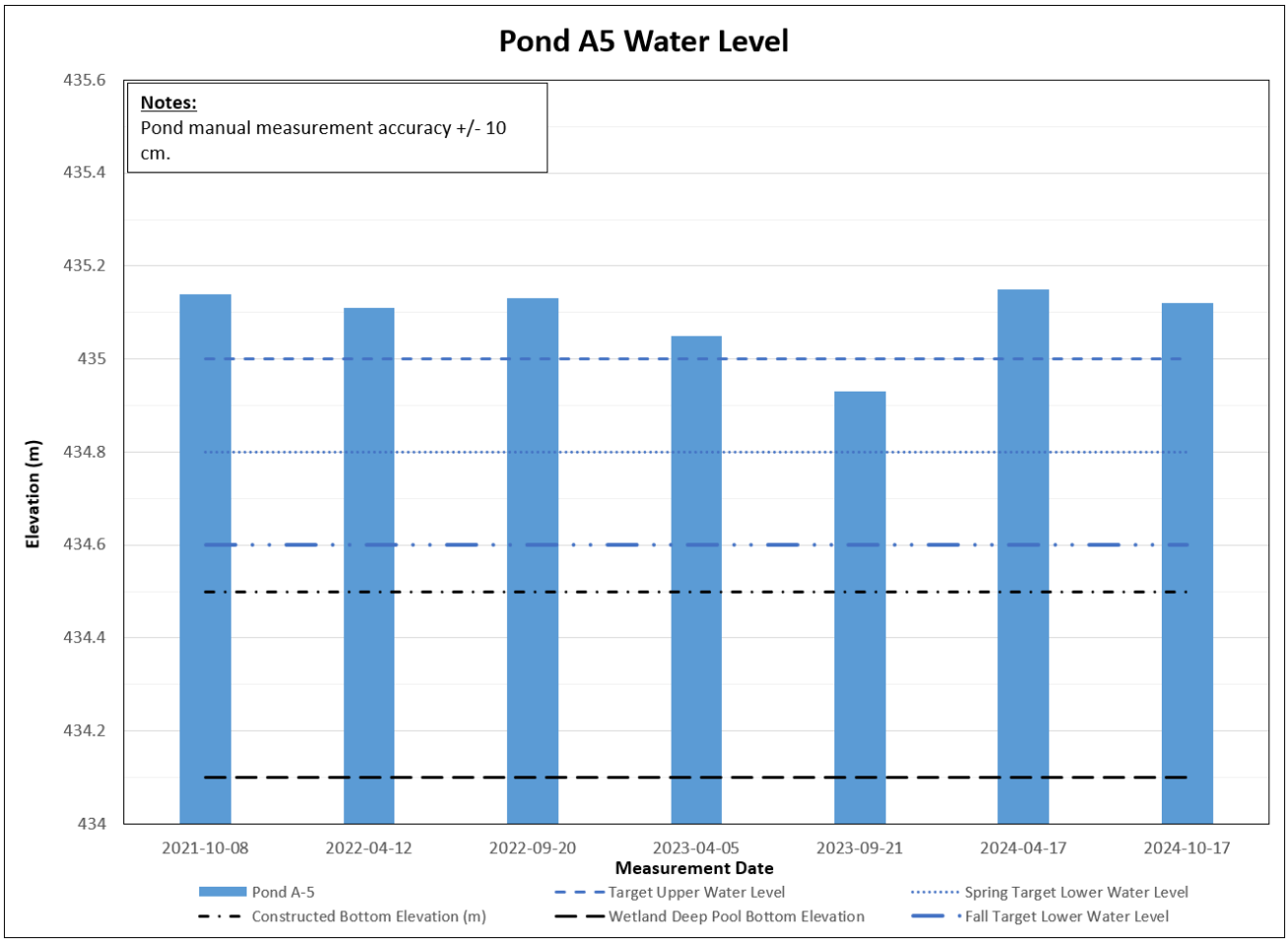

Photo 1: 2024-04-17 Pond A5

Photo 2: 2024-10-17 Pond A5

Pond A6

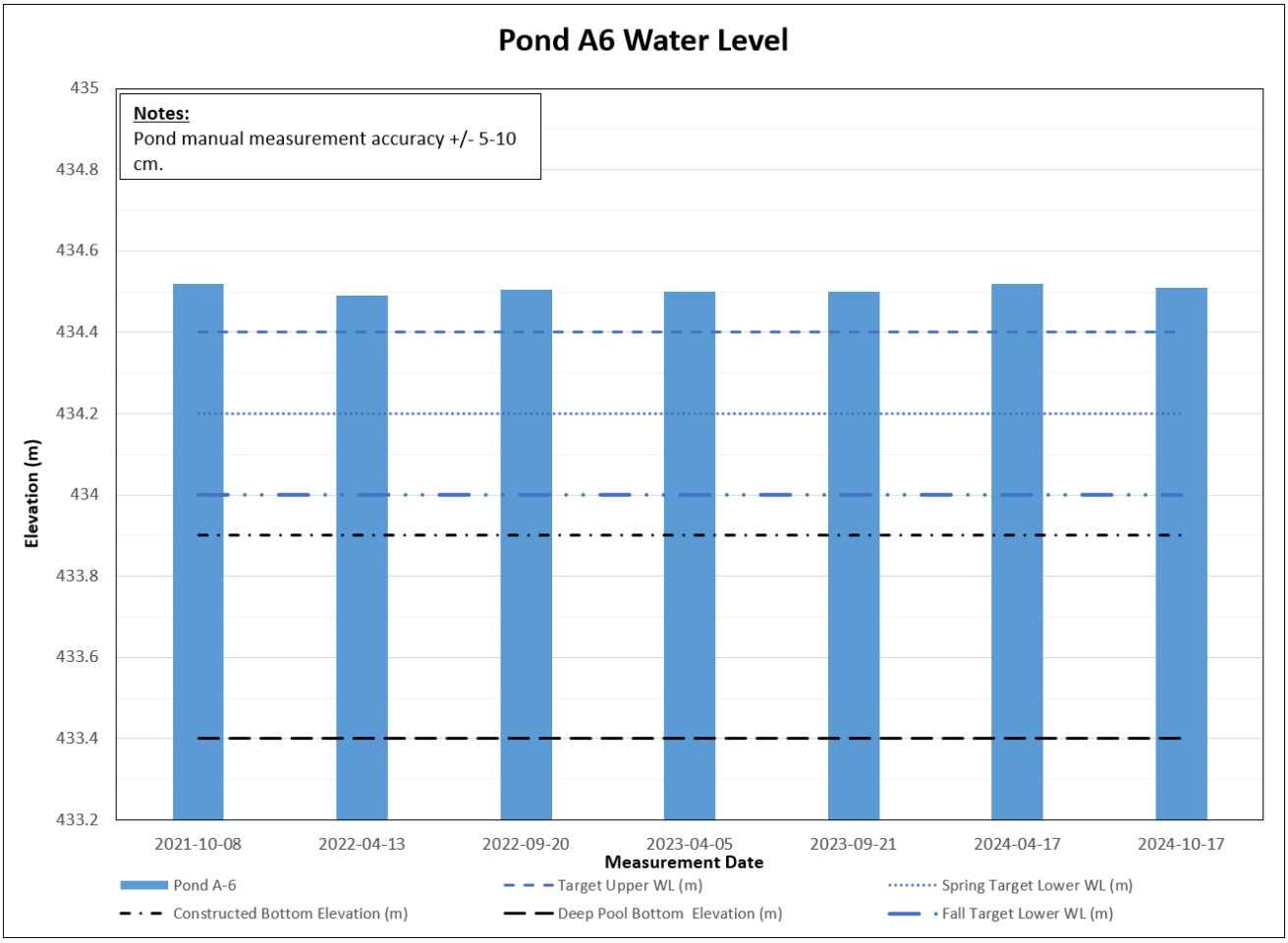

Photo 1: 2024-04-17 Pond A6

Photo 2: 2024-10-17 Pond A6

Pond B1

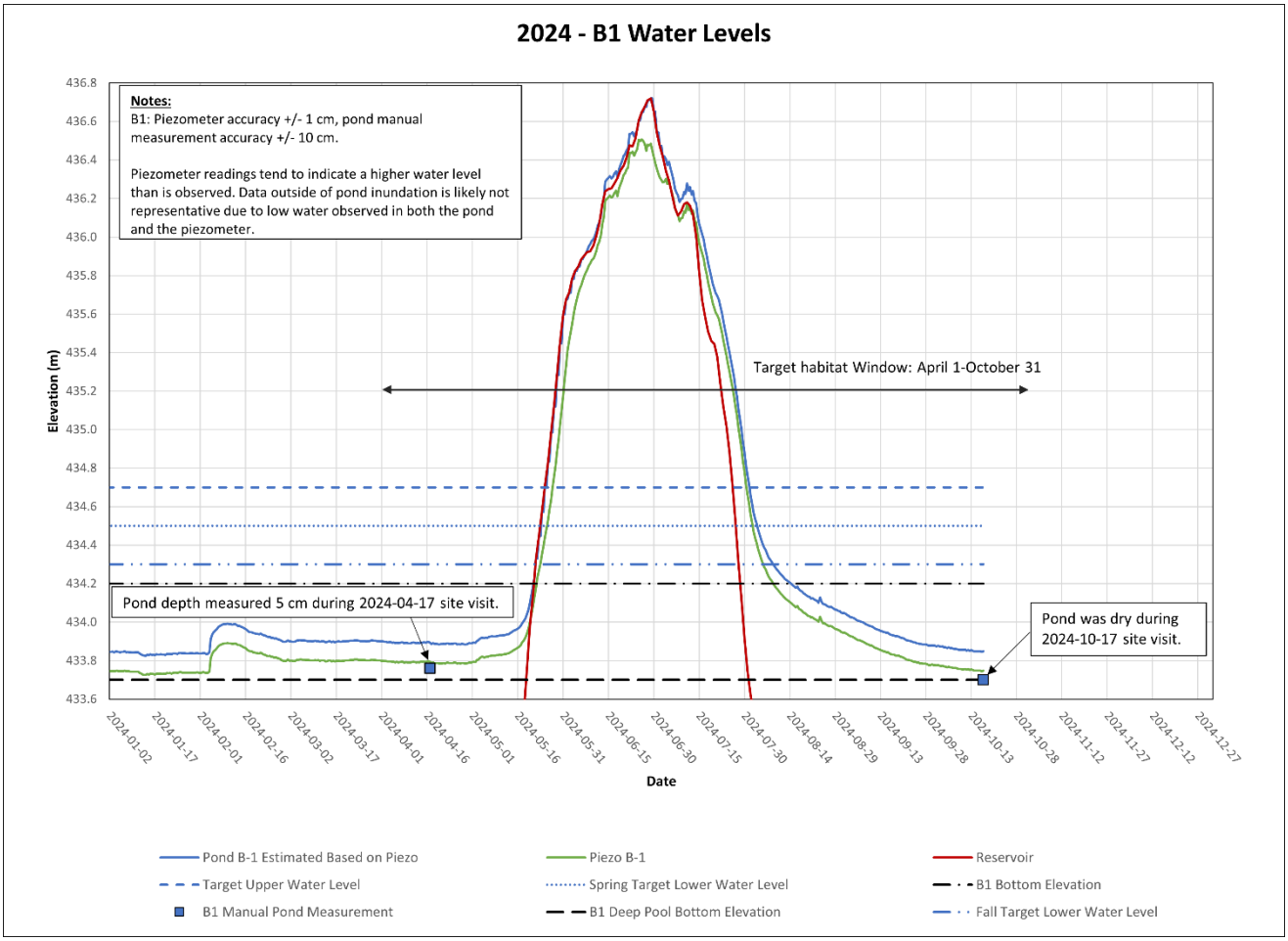

Photo 1: 2024-04-17 Pond B1

Photo 2: 2024-10-17 Pond B1

Pond B2

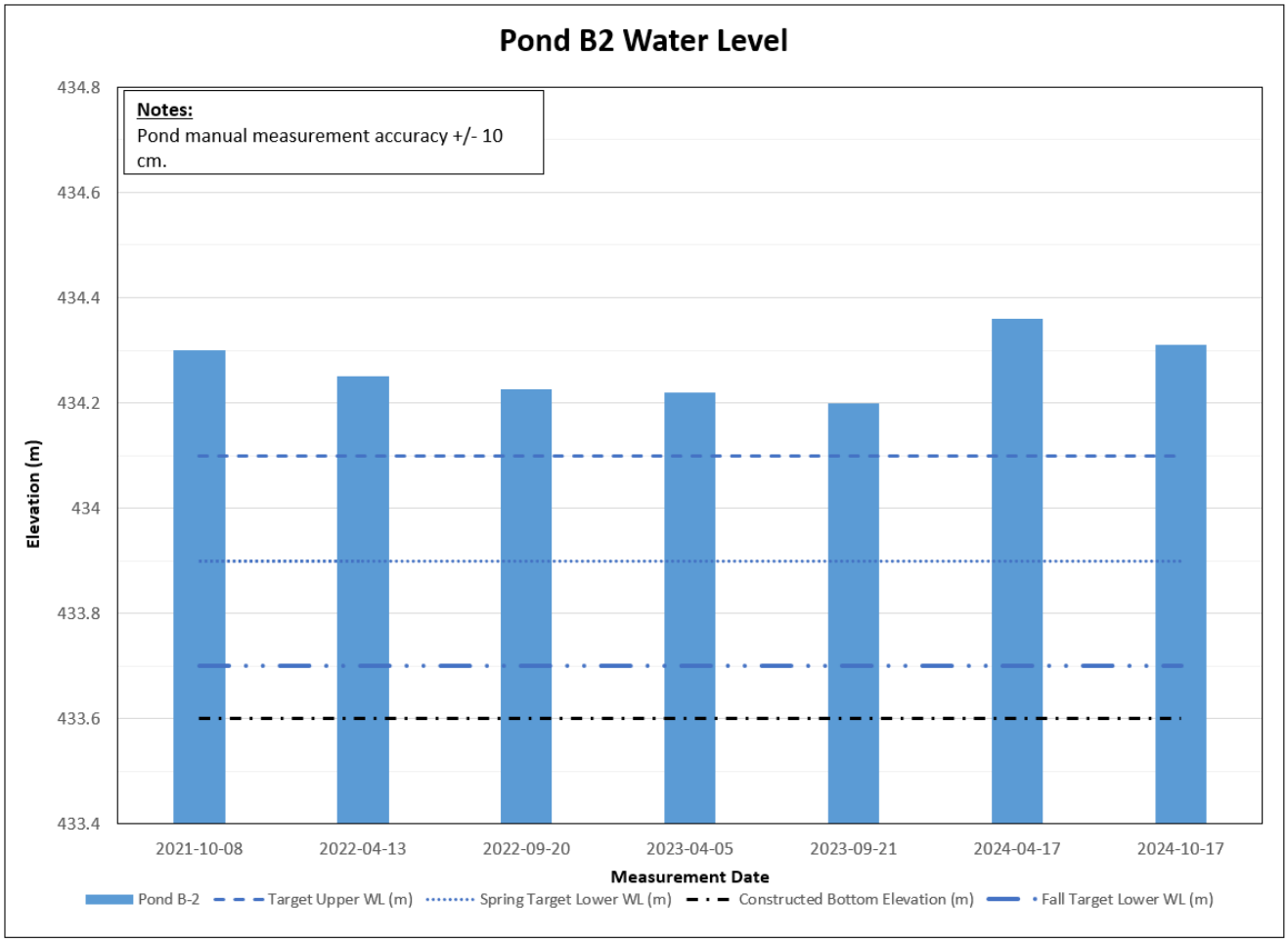

Photo 1: 2024-04-17 Pond B2

Photo 2: 2024-10-17 Pond B2

Pond D1

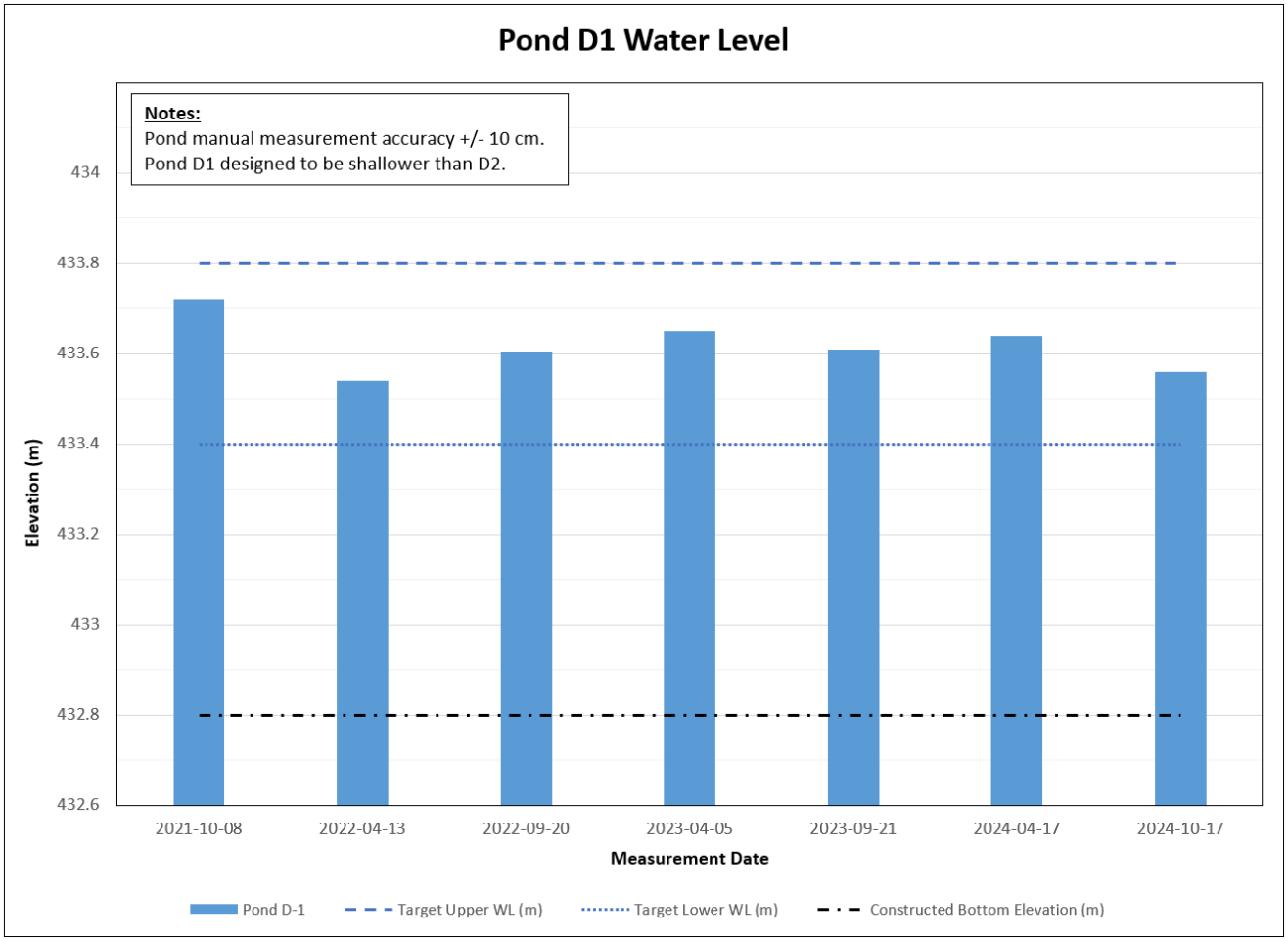

Photo 1: 2024-04-17 Pond D1

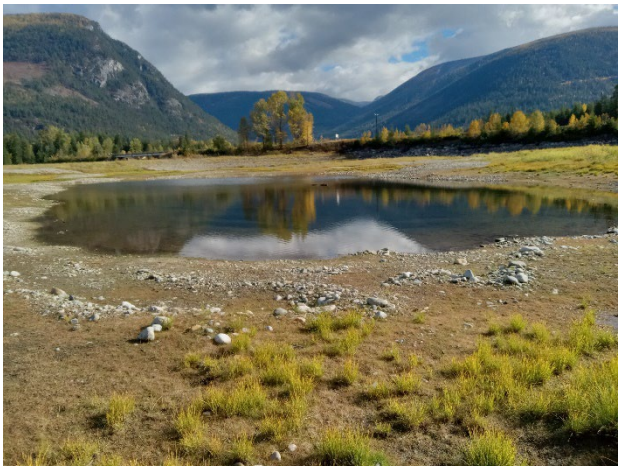

Photo 2: 2024-10-17 Pond D1

Pond D2

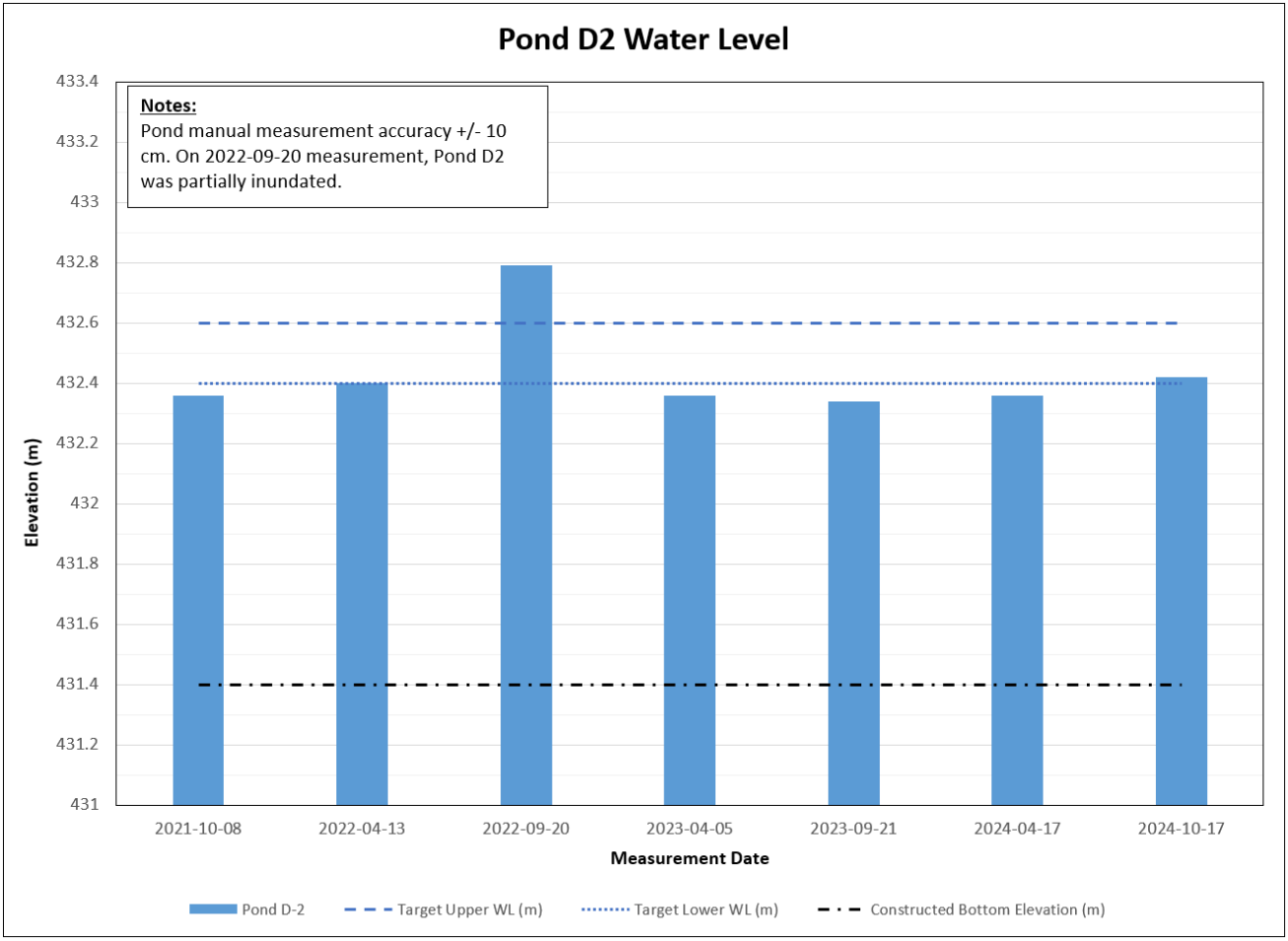

Photo 1: 2024-04-17 Pond D2

Photo 2: 2024-10-17 Pond D2

Burton Creek

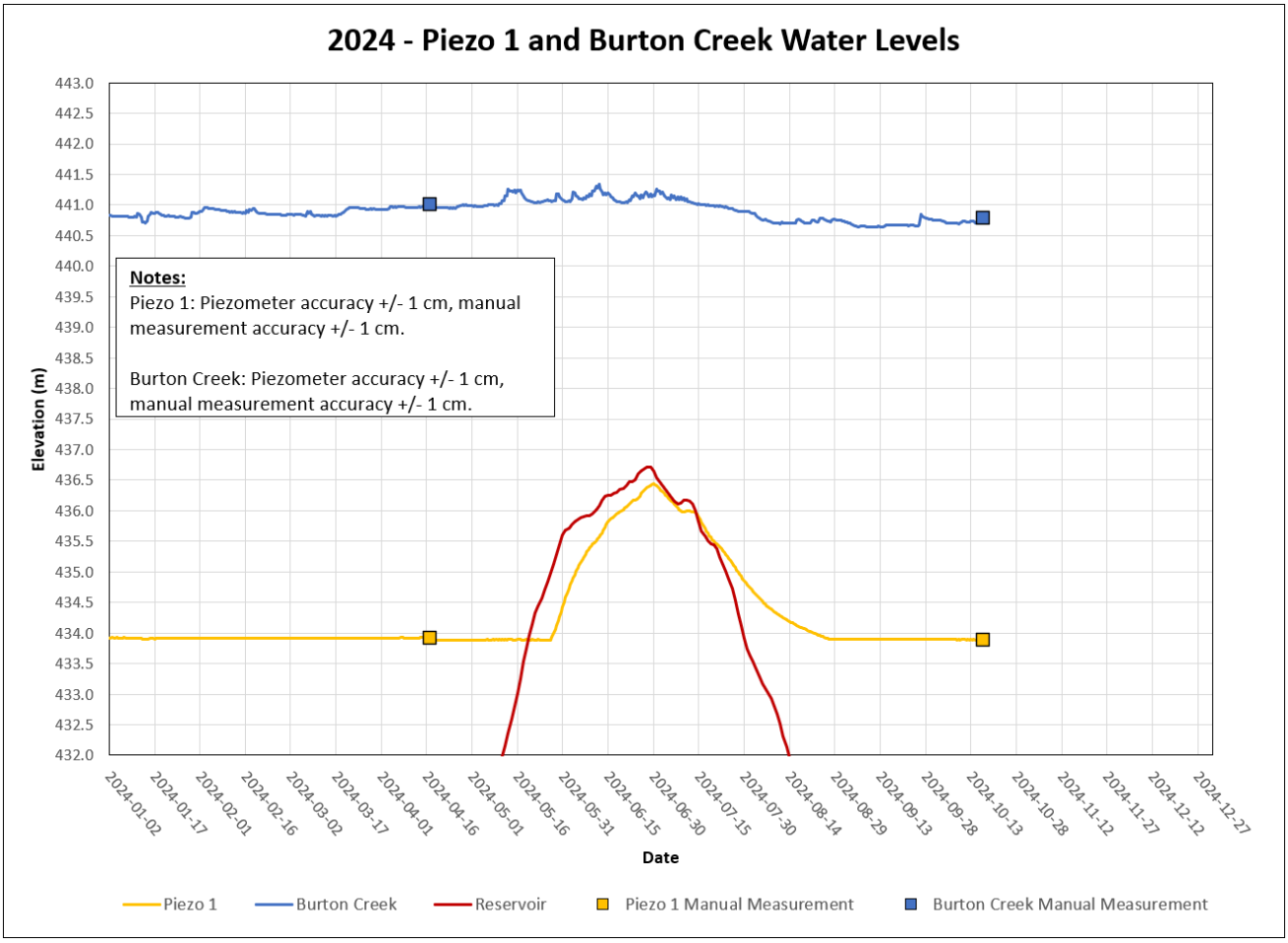

Photo 1: 2024-04-17 Burton Creek

Photo 2: 2024-10-17 Burton Creek

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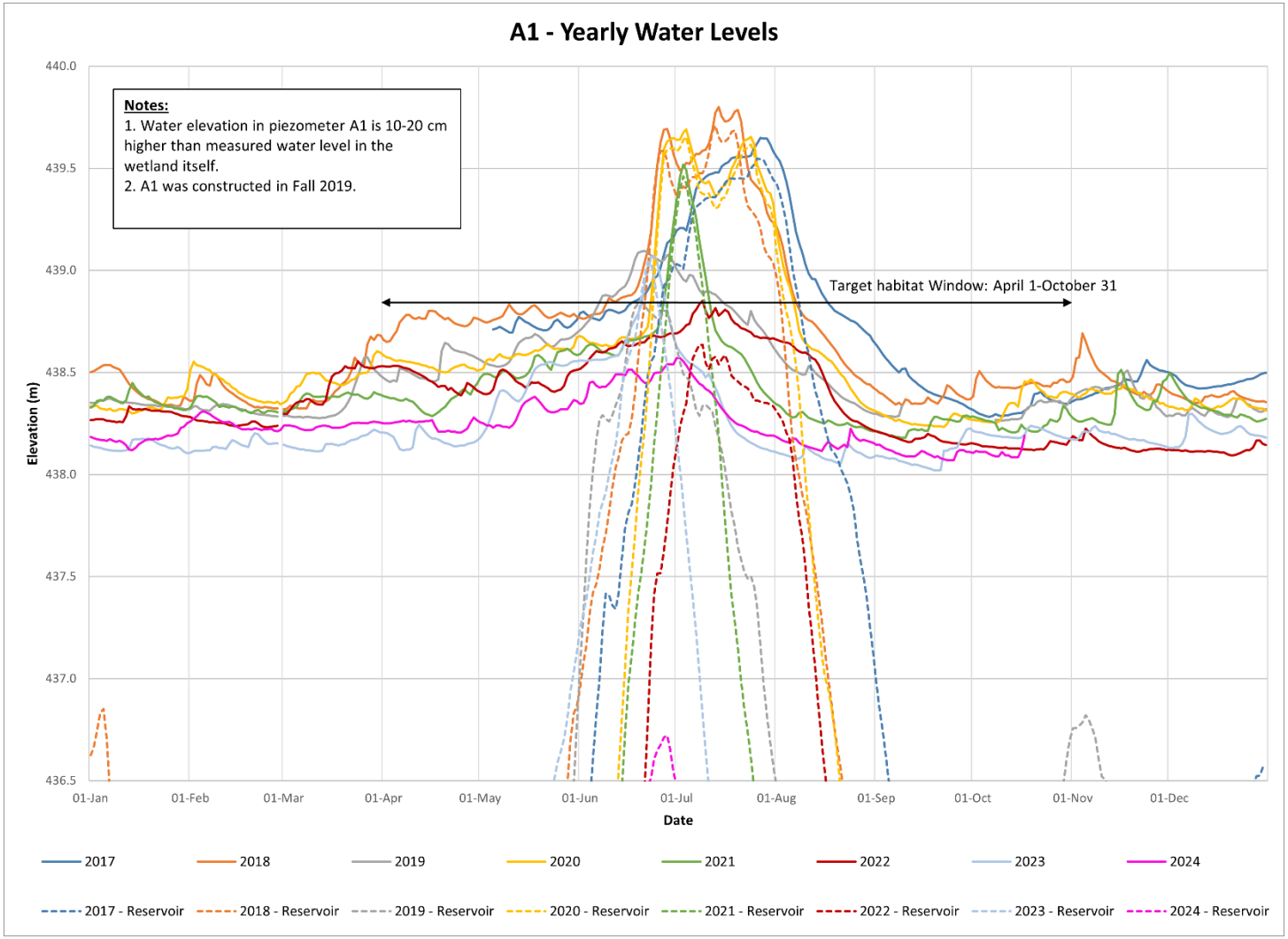
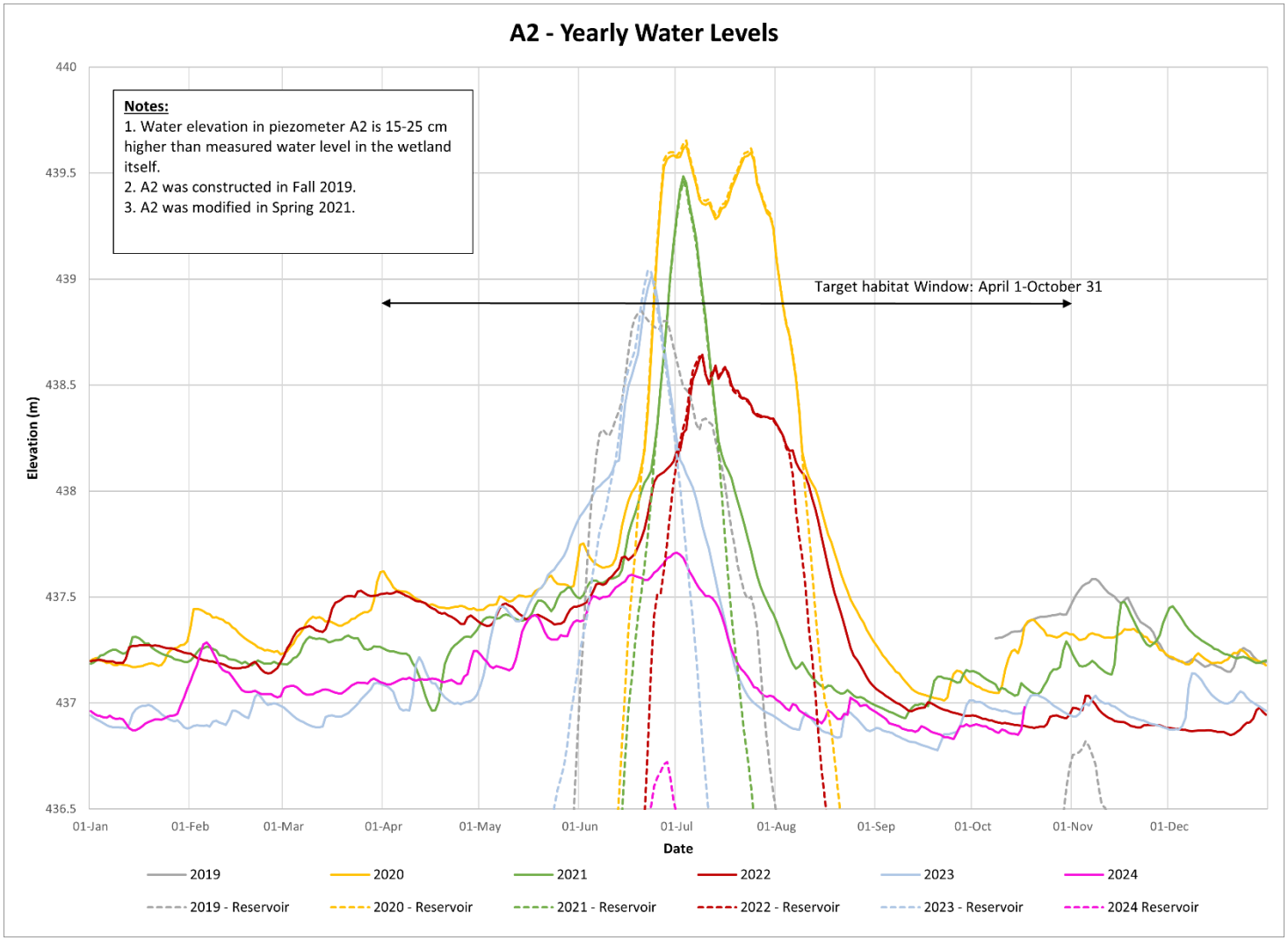
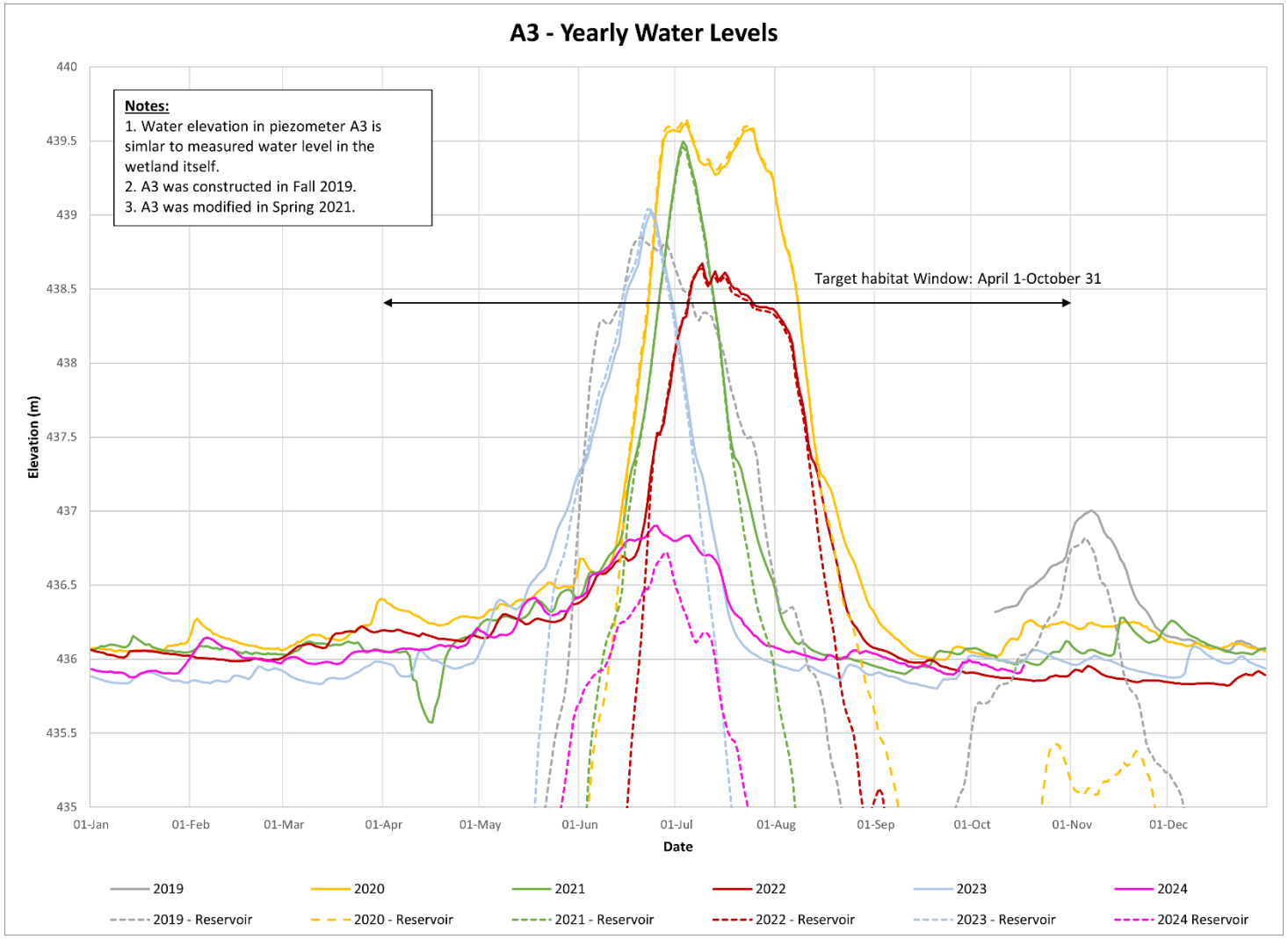
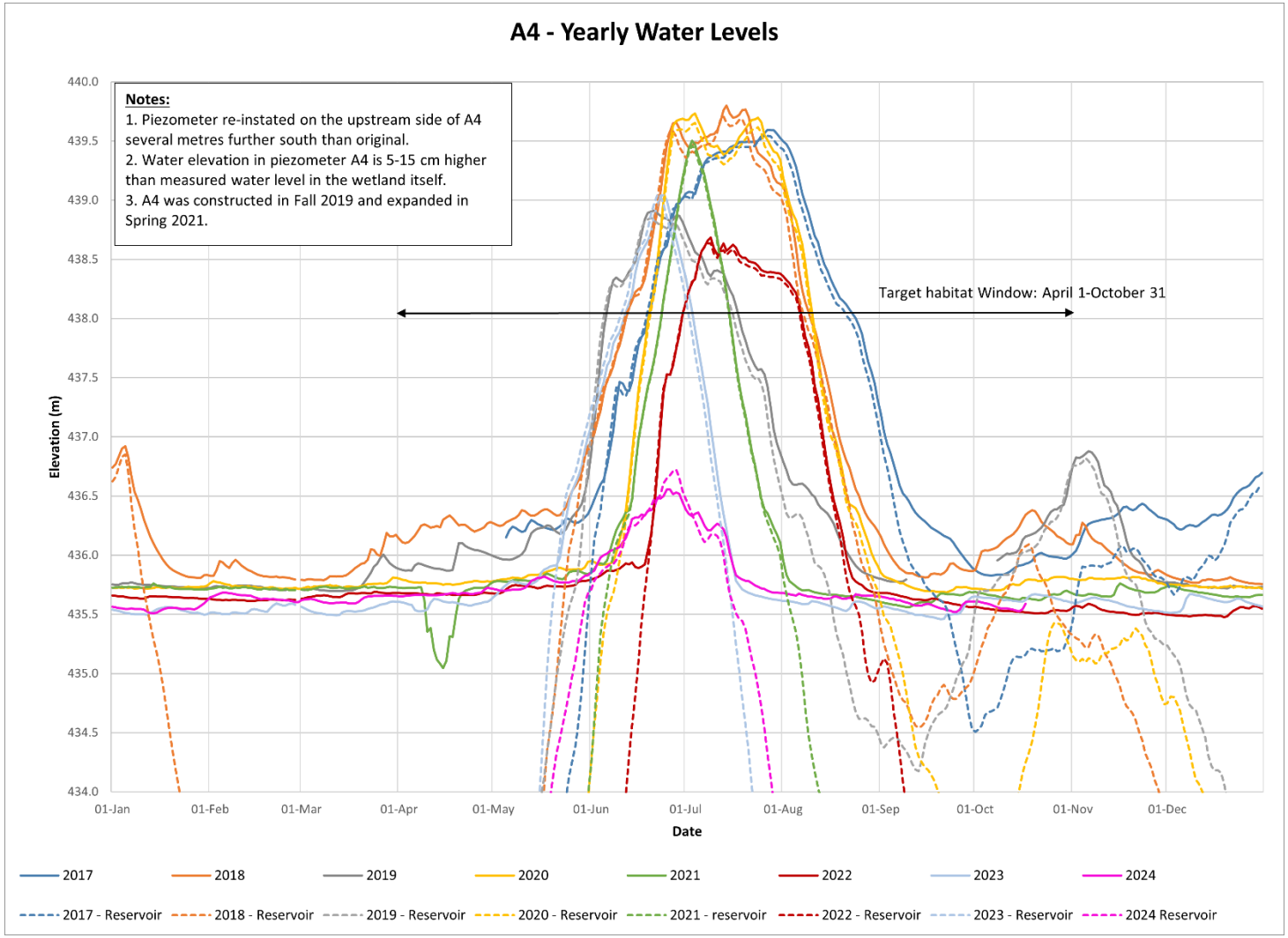
Enclosure 6

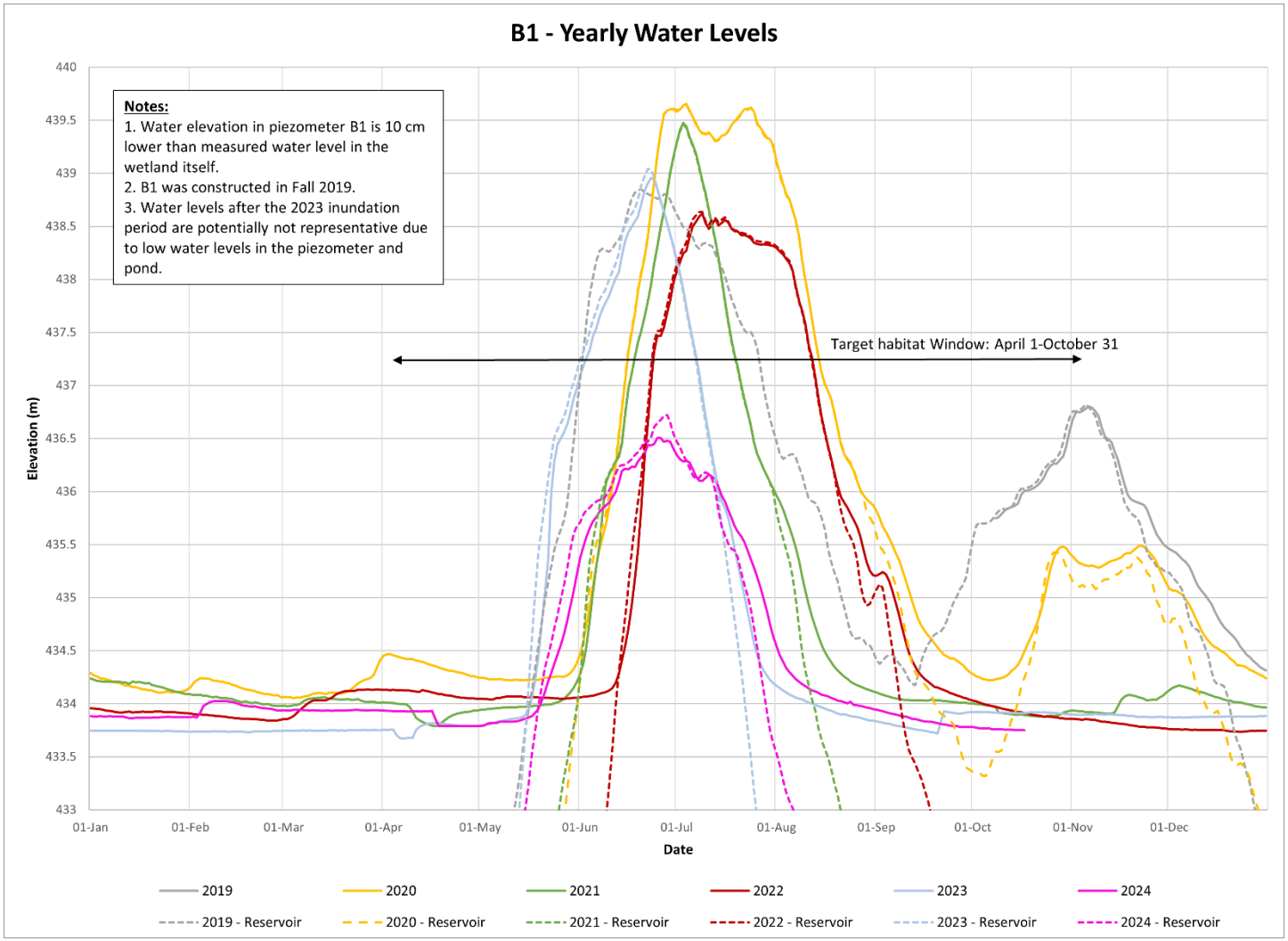
2017-2024 Water Level Monitoring Results

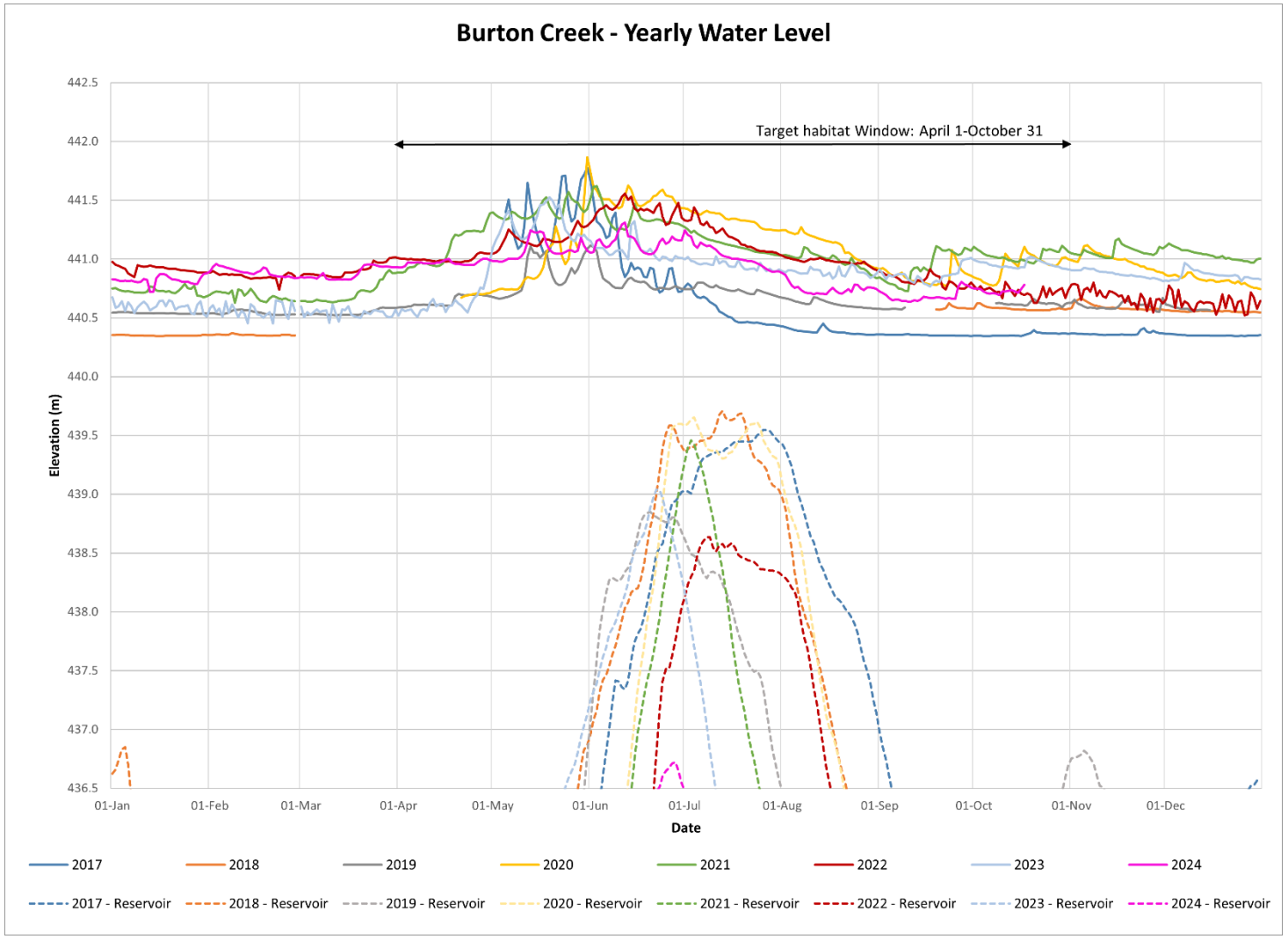

A1 - Yearly Water Levels
Notes:
1. Water elevation in piezometer A1 is 10-20 cm higher than measured water level in the wetland itself.
2. A1 was constructed in Fall 2019.
Target habitat Window: April 1-October 31
Elevation (m)
440.0
439.5
439.0
438.5
438.0
437.5
437.0
436.5
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
Date
2017
2018
2019
2020
2021
2022
2023
2024
2017 - Reservoir
2018 - Reservoir
2019 - Reservoir
2020 - Reservoir
2021 - Reservoir
2022 - Reservoir
2023 - Reservoir
2024 - Reservoir

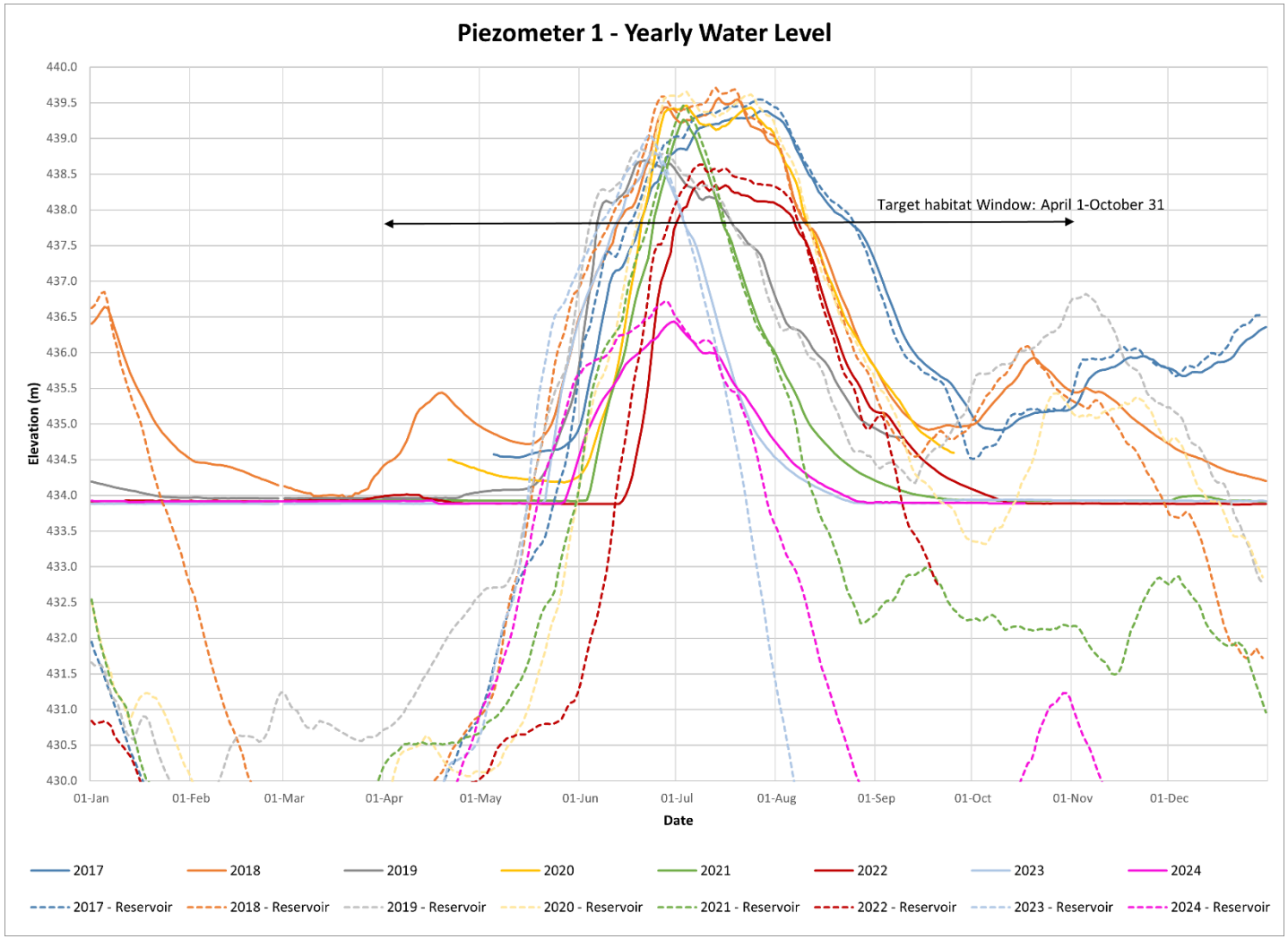

A2 - Yearly Water Levels
Notes:
1. Water elevation in piezometer A2 is 15-25 cm higher than measured water level in the wetland itself.
2. A2 was constructed in Fall 2019.
3. A2 was modified in Spring 2021.
Target habitat Window: April 1-October 31
Elevation (m)
440
439.5
439
438.5
438
437.5
437
436.5
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
Date
2019
2020
2021
2022
2023
2024
2019 - Reservoir
2020 - Reservoir
2021 - Reservoir
2022 - Reservoir
2023 - Reservoir
2024 Reservoir


A3 - Yearly Water Levels
Notes:
1. Water elevation in piezometer A3 is simlar to measured water level in the wetland itself.
2. A3 was constructed in Fall 2019.
3. A3 was modified in Spring 2021.
Target habitat Window: April 1-October 31
Elevation (m)
440
439.5
439
438.5
438
437.5
437
436.5
436
435.5
435
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
Date
2019
2020
2021
2022
2023
2024
2019 - Reservoir
2020 - Reservoir
2021 - Reservoir
2022 - Reservoir
2023 - Reservoir
2024 Reservoir


A4 - Yearly Water Levels
Notes:
1. Piezometer re-instated on the upstream side of A4 several metres further south than original.
2. Water elevation in piezometer A4 is 5-15 cm higher than measured water level in the wetland itself.
3. A4 was constructed in Fall 2019 and expanded in Spring 2021.
Target habitat Window: April 1-October 31
Elevation (m)
440.0
439.5
439.0
438.5
438.0
437.5
437.0
436.5
436.0
435.5
435.0
434.5
434.0
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
Date
2017
2018
2019
2020
2021
2022
2023
2024
2017 - Reservoir
2018 - Reservoir
2019 - Reservoir
2020 - Reservoir
2021 - reservoir
2022 - Reservoir
2023 - Reservoir
2024 Reservoir


B1 - Yearly Water Levels
Notes:
1. Water elevation in piezometer B1 is 10 cm lower than measured water level in the wetland itself.
2. B1 was constructed in Fall 2019.
3. Water levels after the 2023 inundation period are potentially not representative due to low water levels in the piezometer and pond.
Target habitat Window: April 1-October 31
Elevation (m)
440
439.5
439
438.5
438
437.5
437
436.5
436
435.5
435
434.5
434
433.5
433
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
Date
2019
2020
2021
2022
2023
2024
2019 - Reservoir
2020 - Reservoir
2021 - Reservoir
2022 - Reservoir
2023 - Reservoir
2024 - Reservoir


Burton Creek - Yearly Water Level
Target habitat Window: April 1-October 31
Elevation (m)
442.5
442.0
441.5
441.0
440.5
440.0
439.5
439.0
438.5
438.0
437.5
437.0
436.5
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
Date
2017
2018
2019
2020
2021
2022
2023
2024
2017 - Reservoir
2018 - Reservoir
2019 - Reservoir
2020 - Reservoir
2021 - Reservoir
2022 - Reservoir
2023 - Reservoir
2024 - Reservoir


Piezometer 1 - Yearly Water Level
Elevation (m)
440.0
439.5
439.0
438.5
438.0
437.5
437.0
436.5
436.0
435.5
435.0
434.5
434.0
433.5
433.0
432.5
432.0
431.5
431.0
430.5
430.0
Target habitat Window: April 1-October 31
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec
Date
2017
2018
2019
2020
2021
2022
2023
2024
2017 - Reservoir
2018 - Reservoir
2019 - Reservoir
2020 - Reservoir
2021 - Reservoir
2022 - Reservoir
2023 - Reservoir
2024 - Reservoir

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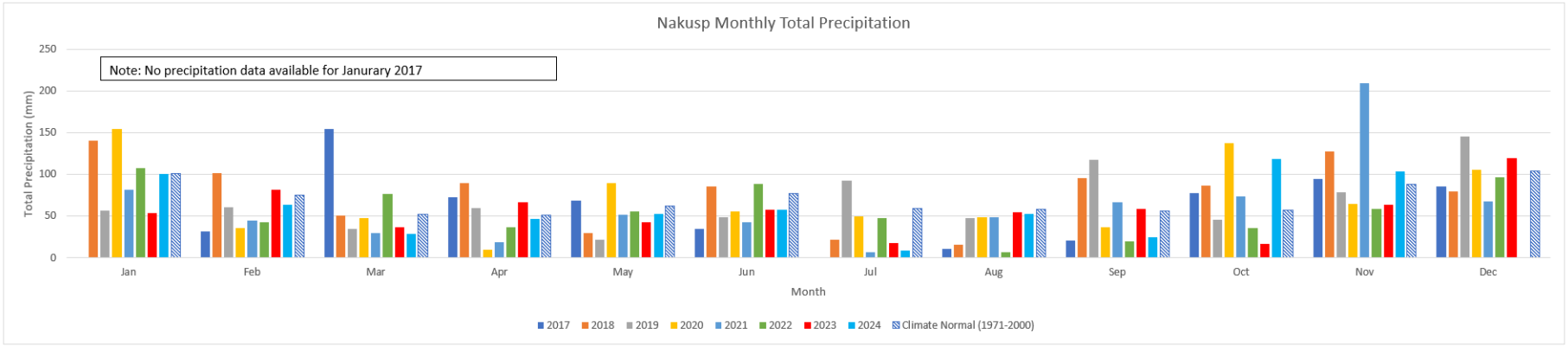
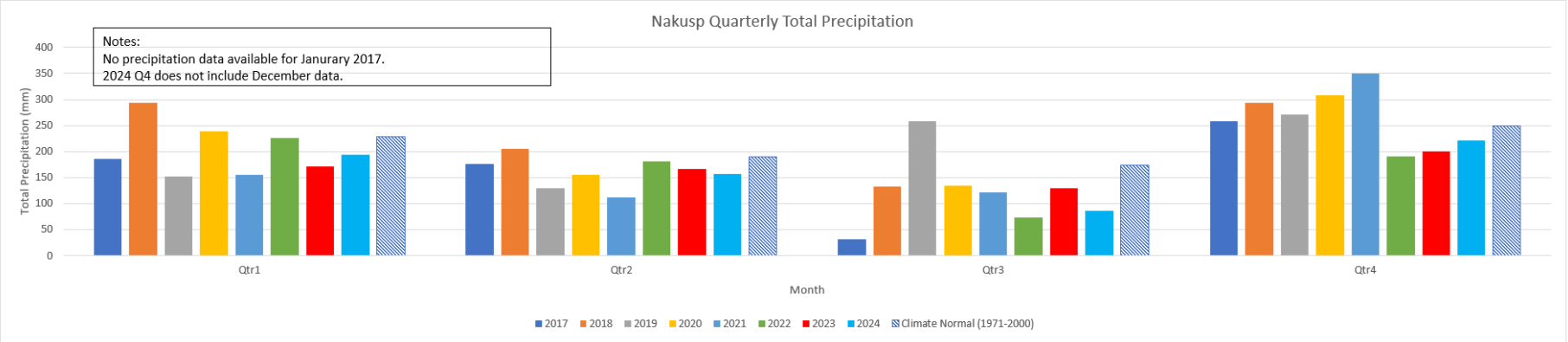
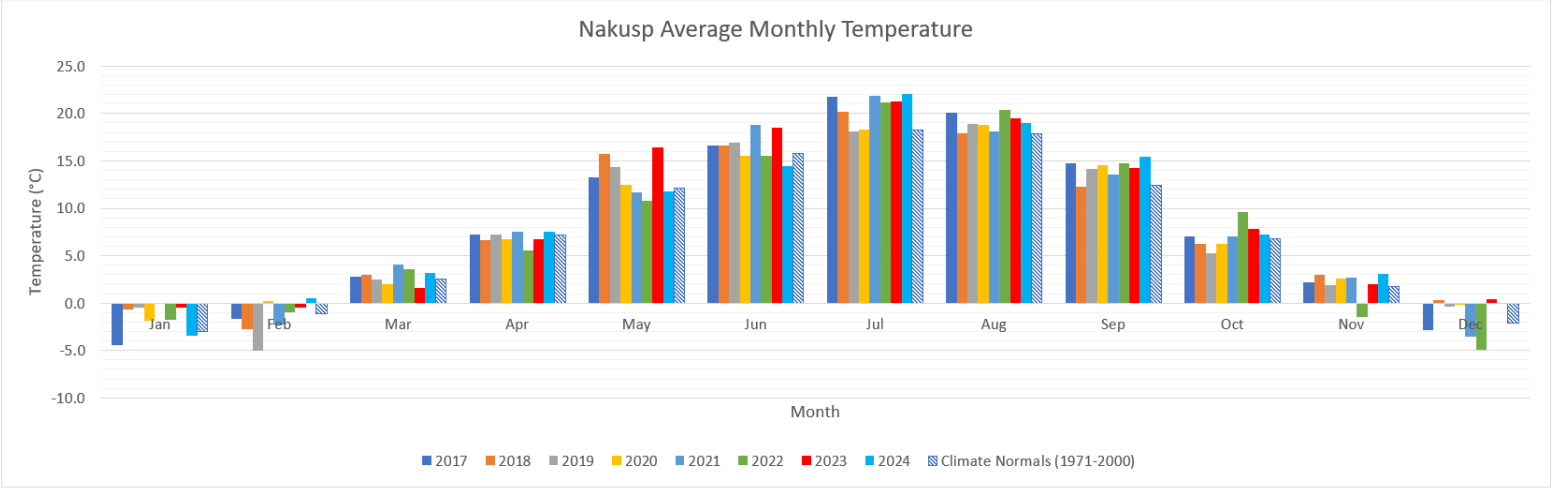
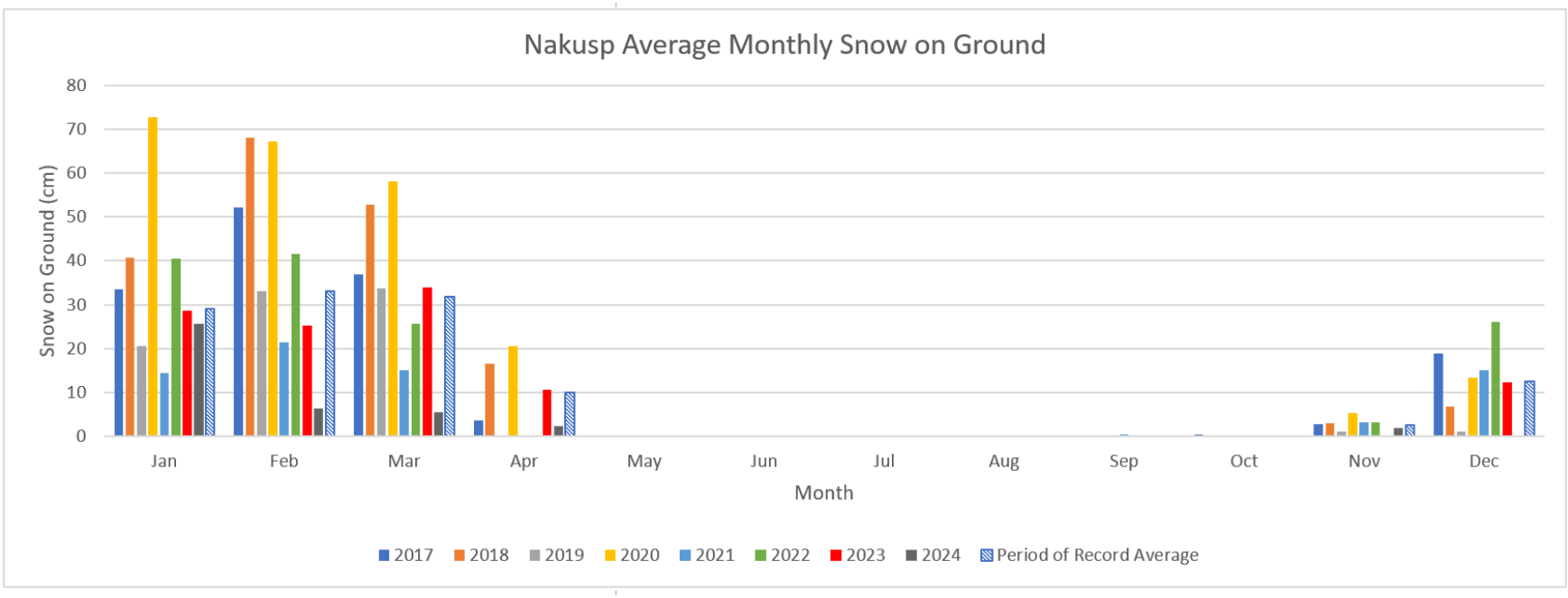
Enclosure 7

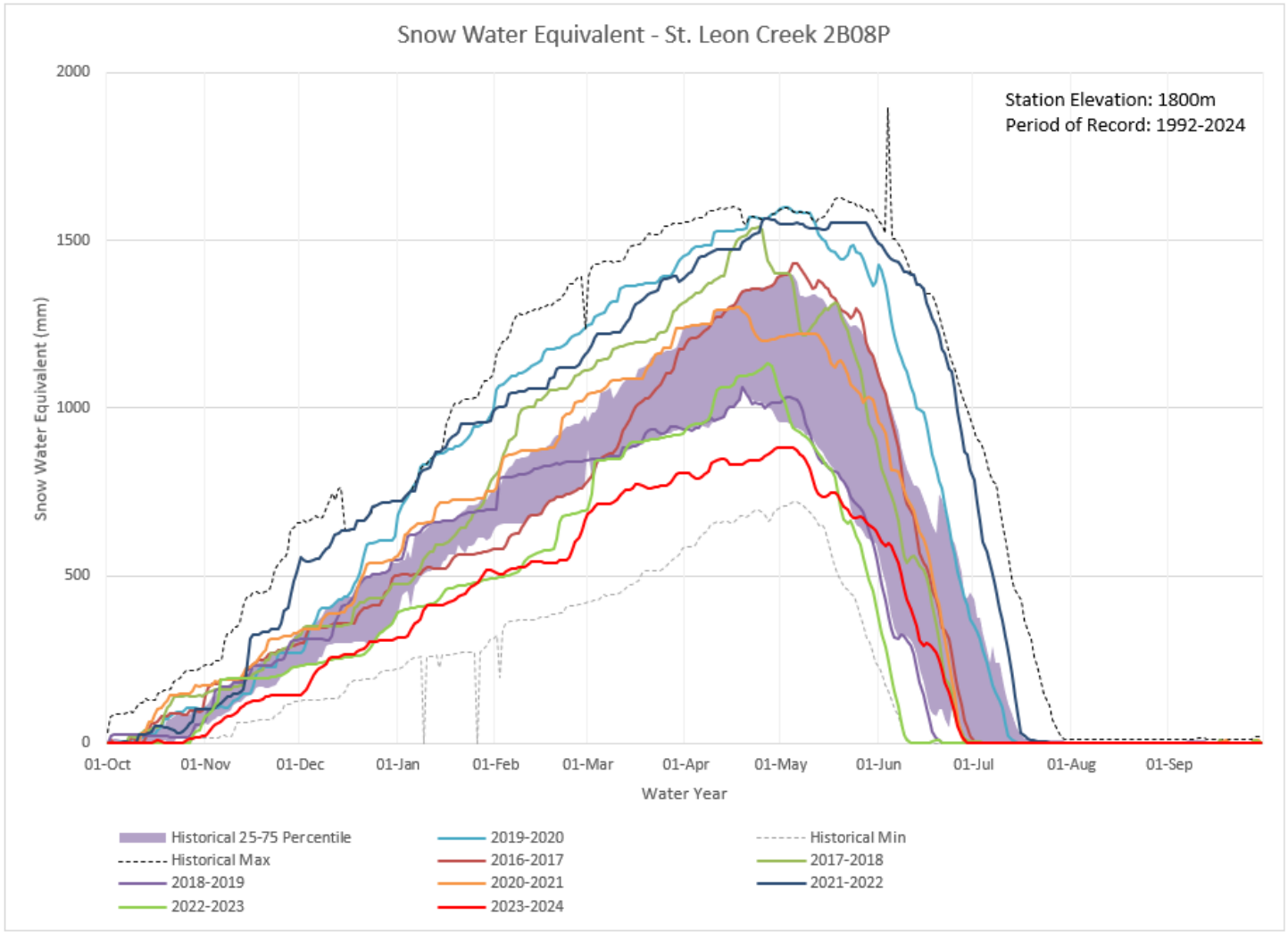
Summary of Local Climatic Conditions

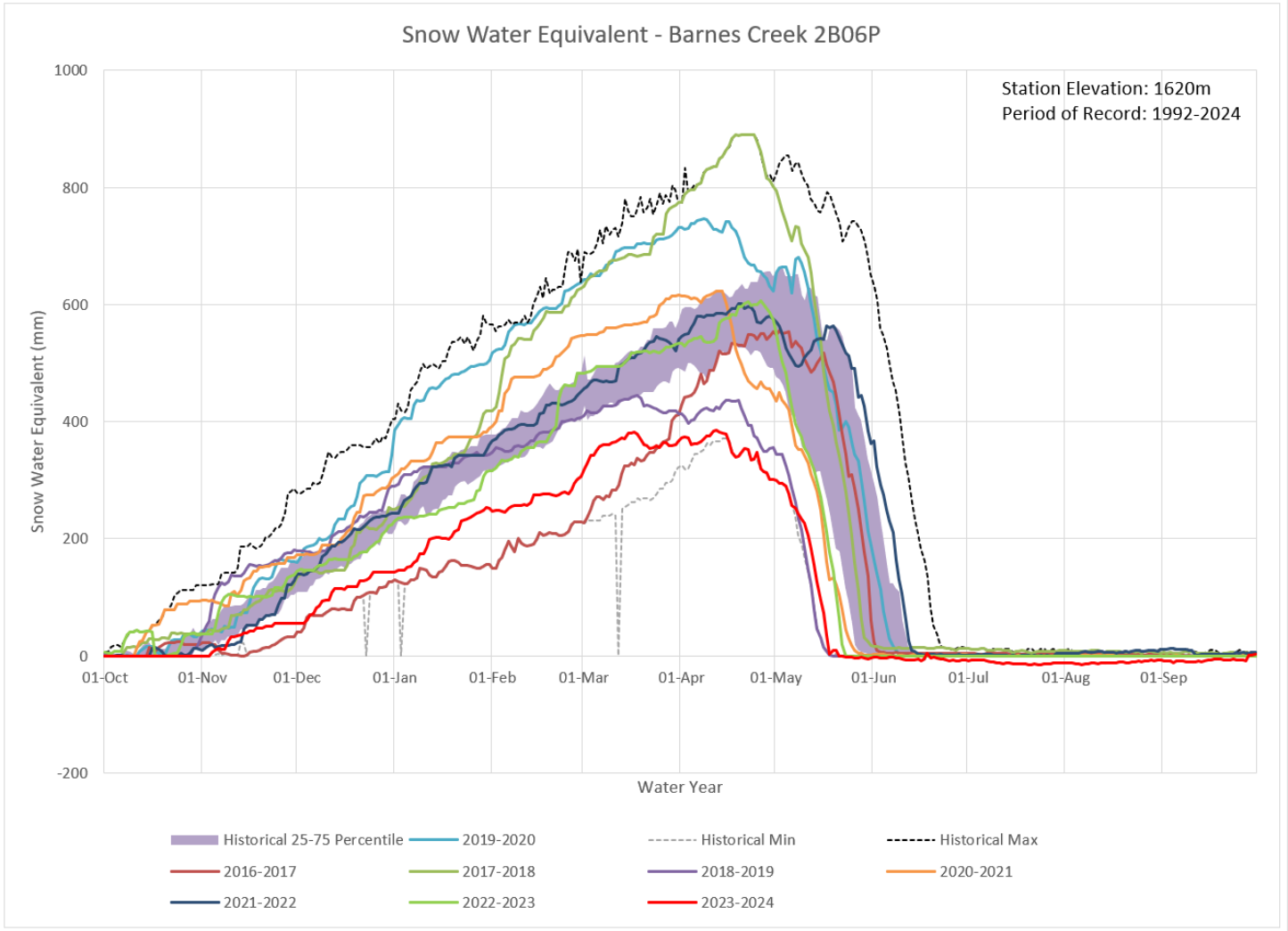

Nakusp Monthly Total Precipitation
Note: No precipitation data available for Janurary 2017
Total Precipitation (mm)
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
2017
2018
2019
2020
2021
2022
2023
2024
Climate Normal (1971-2000)

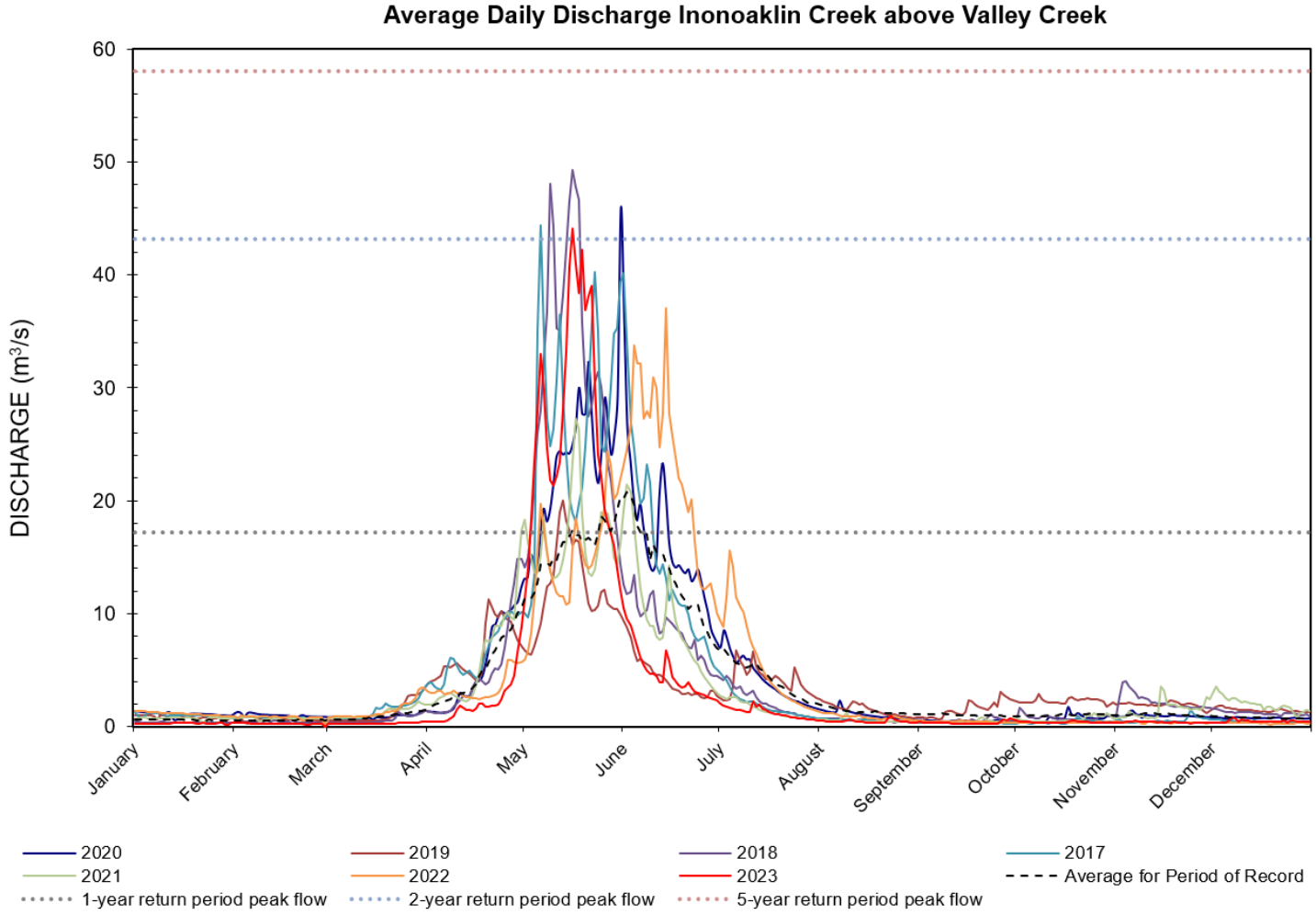

Nakusp Quarterly Total Precipitation
Notes:
No precipitation data available for Janurary 2017.
2024 Q4 does not include December data.
Total Precipitation (mm)
400
350
300
250
200
150
100
50
0
Qtr1
Qtr2
Qtr3
Qtr4
Month
2017
2018
2019
2020
2021
2022
2023
2024
Climate Normal (1971-2000)


Nakusp Average Monthly Temperature
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
Temperature (°C)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
2017
2018
2019
2020
2021
2022
2023
2024
Climate Normals (1971-2000)


Nakusp Average Monthly Snow on Ground
Snow on Ground (cm)
80
70
60
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
2017
2018
2019
2020
2021
2022
2023
2024
Period of Record Average


Snow Water Equivalent - St. Leon Creek 2B08P
Station Elevation: 1800m
Period of Record: 1992-2024
Snow Water Equivalent (mm)
2000
1500
1000
500
0
01-Oct
01-Nov
01-Dec
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
01-Sep
Water Year
Historical 25-75 Percentile
Historical Max
2018-2019
2022-2023
2019-2020
2016-2017
2020-2021
2023-2024
Historical Min
2017-2018
2021-2022

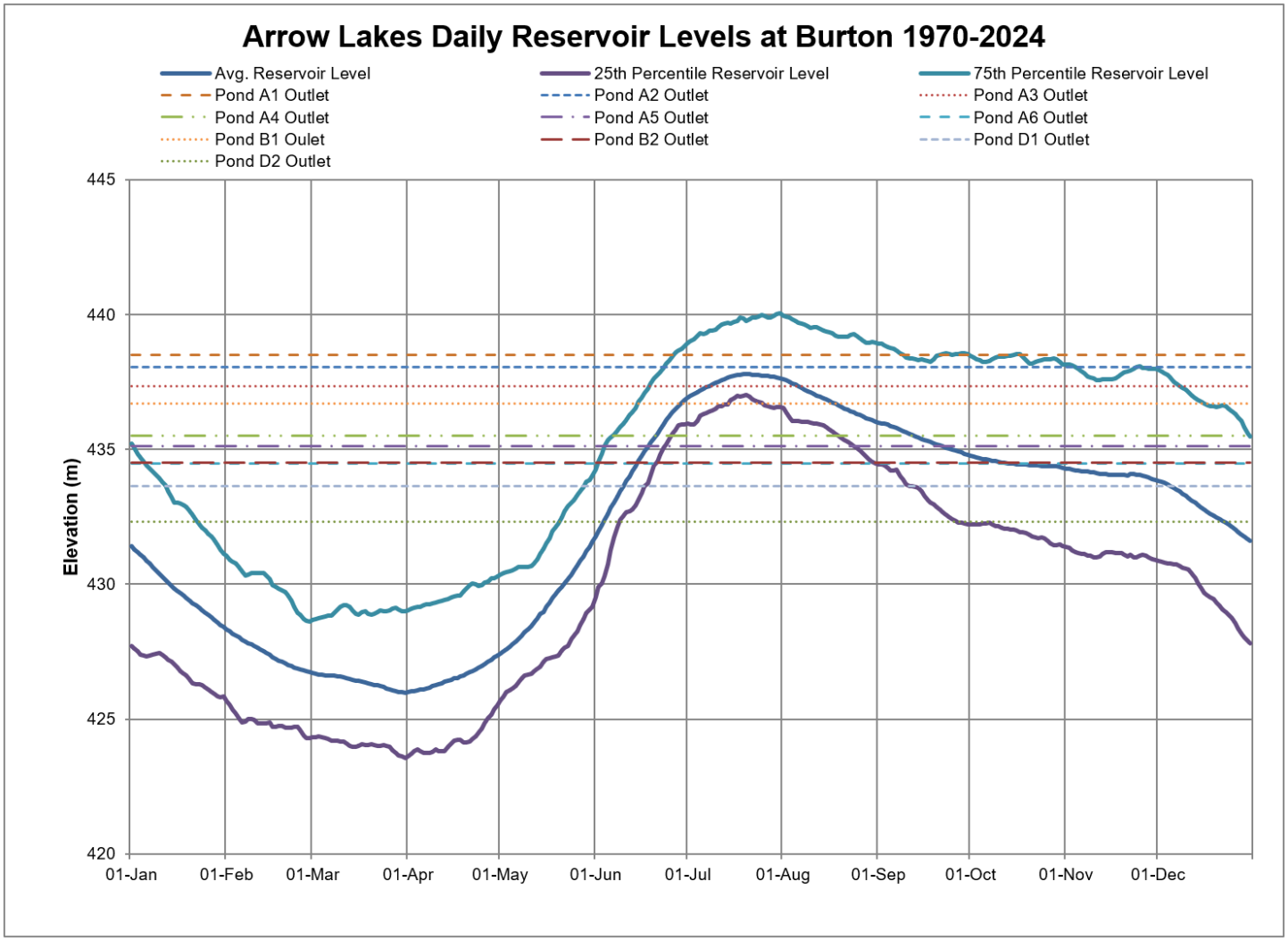

Snow Water Equivalent - Barnes Creek 2B06P
Station Elevation: 1620m
Period of Record: 1992-2024
Snow Water Equivalent (mm)
1000
800
600
400
200
0
-200
01-Oct
01-Nov
01-Dec
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
01-Sep
Water Year
Historical 25-75 Percentile
2019-2020
Historical Min
Historical Max
2016-2017
2017-2018
2018-2019
2020-2021
2021-2022
2022-2023
2023-2024

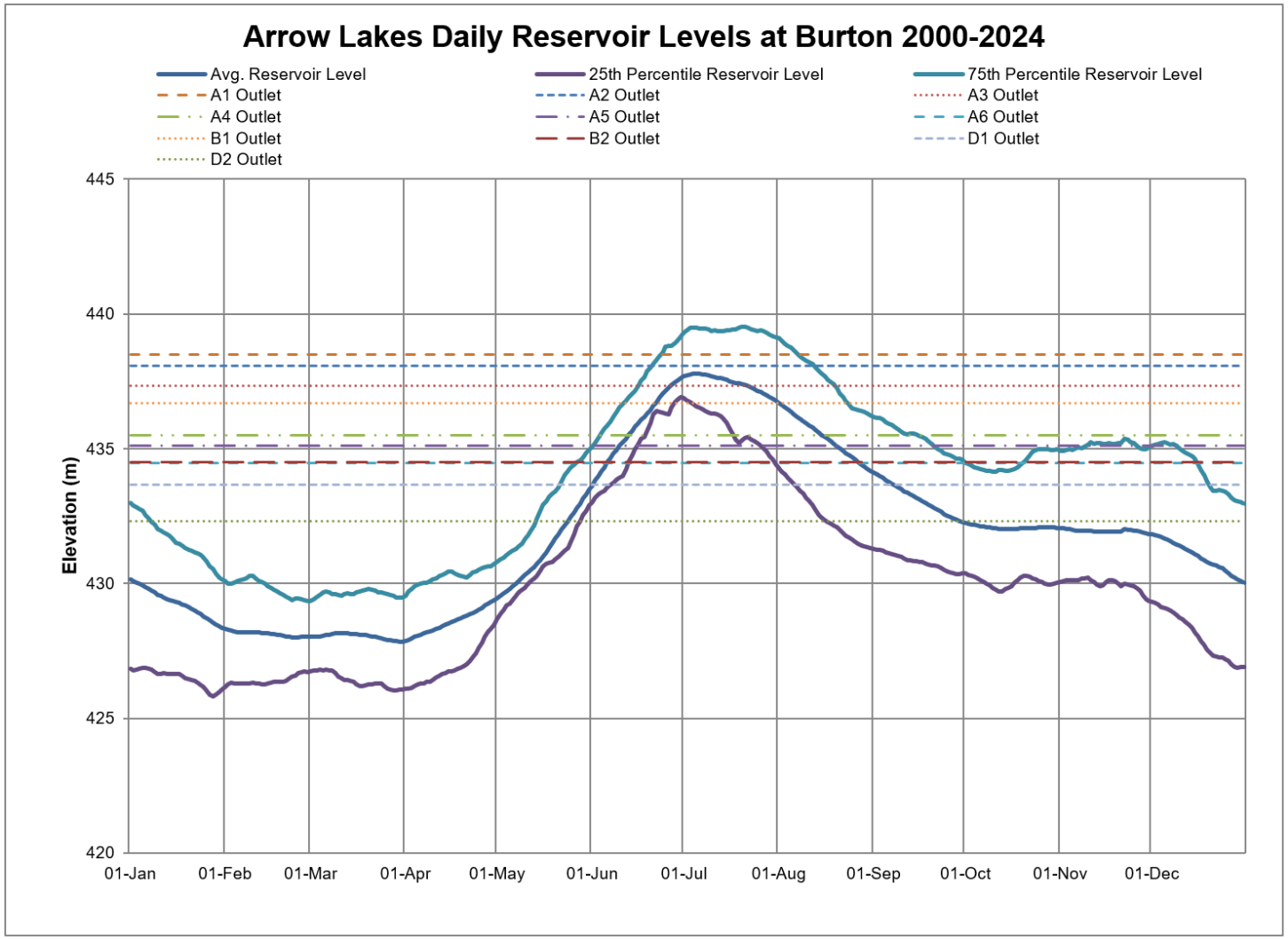

Average Daily Discharge Inonoaklin Creek above Valley Creek
DISCHARGE (m3/s)
60
50
40
30
20
10
0
January
February
March
April
May
June
July
August
September
October
November
December
2020
2019
2018
2017
2021
2022
2023
Average for Period of Record
1-year return period peak flow
2-year return period peak flow
5-year return period peak flow

KERR WOOD LEIDAL
consulting engineers

Enclosure 8

Long Term Reservoir Elevations


Arrow Lakes Daily Reservoir Levels at Burton 1970-2024
Avg. Reservoir Level
25th Percentile Reservoir Level
75th Percentile Reservoir Level
Pond A1 Outlet
Pond A2 Outlet
Pond A3 Outlet
Pond A4 Outlet
Pond A5 Outlet
Pond A6 Outlet
Pond B1 Oulet
Pond B2 Outlet
Pond D1 Outlet
Pond D2 Outlet
Elevation (m)
445
440
435
430
425
420
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec


Arrow Lakes Daily Reservoir Levels at Burton 2000-2024
Avg. Reservoir Level
25th Percentile Reservoir Level
75th Percentile Reservoir Level
A1 Outlet
A2 Outlet
A3 Outlet
A4 Outlet
A5 Outlet
A6 Outlet
B1 Outlet
B2 Outlet
D1 Outlet
D2 Outlet
Elevation (m)
445
440
435
430
425
420
01-Jan
01-Feb
01-Mar
01-Apr
01-May
01-Jun
01-Jul
01-Aug
01-Sep
01-Oct
01-Nov
01-Dec