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| **Cottonwood ranch broad-scale recharge** | |
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| **2021** | **Summer 2020 Test Fills Report** | |
| **Description: Final Color Platte Logo.jpg** | Prepared by Executive Director’s Office of the  **Platte River Recovery Implementation Program**  4111 4th Avenue, Suite 6  Kearney, NE 68845  January 26, 2021  Draft for Review by WAC  Version 1.0  PRINT IN COLOR | |

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# Introduction

Construction of the Cottonwood Ranch (CWR) Broad-Scale Recharge (BSR) project was completed in the fall of 2019. The project was constructed by the Platte River Recovery Implementation Program (Program) to re-time flows in the Platte River via groundwater recharge.[[1]](#footnote-1) Although construction was completed in 2019, operations could not occur until adequate vegetation had established on the berms and swales used to pond and convey water around the project. The project was deemed ready for deliveries in the summer of 2020. Three test fills ensued, one each in July, August, and September. This report summarizes the fillings. It includes a brief summary regarding performance of major pieces of project infrastructure (section 2), and proceeds to sections that summarize daily deliveries, routing and accounting (section 3), and local groundwater and surface water monitoring (section 4). A detailed project map is included in **Appendix A** for reference.

# Infrastructure

The large pieces of infrastructure at the CWR BSR project that required operational testing during the first fills were the delivery pipeline, water control structures, and earthen berms. In general, all infrastructure performed adequately. Important information is summarized below.



**Figure 1**: North delivery structure/pipeline outlet showing baffle wall and rip-rap control section. Open-air pipe outlet cannot be seen but exists behind the baffle structure, projecting from the concrete wall.

## Pipeline & Discharge Structures

Water from the Phelps County Canal is supplied to the CWR BSR project via a 42-inch diameter PVC pipeline. The pipeline has two outlets: a south outlet that discharges water to cell 1 and a north outlet that discharges water to cell 3. Each outlet consists of an open-air discharge into a baffle wall (**Figure 1**). Deliveries are regulated by a valve near each outlet. Important notes regarding performance of the pipeline and discharge structure are presented below:

* The 42-inch delivery pipeline performed well during the test fills. There were no issues with the intake structure at the canal, the pipeline, the air relief valves that are located on the pipeline between the canal and the project, or the butterfly valve located near the southern boundary of the project.
* The maximum sustainable delivery rate when delivering water to only cell 1 was about 75 cubic feet per second (cfs), and the maximum sustainable delivery rate to cell 3 was about 50 cfs. Deliveries during the test fills were made either to cell 1 or cell 3. Concurrently deliveries are anticipated but were not tested in 2020.
* The north and south discharge structures performed well during the fills. The baffle wall and rip rap sections (**Figure 1**) remained stable.
* The operating valves near each outlet successfully regulated deliveries. However, when the operating valves were partially open (between approximately 20 and 60%), there appeared to be beginning stage cavitation on or near the valves. This occurred only at intermediate flows when one outlet was open and the other was closed. Consequently, the deliveries through each structure during the fills were either less than 20 cfs or greater than approximately 60 cfs in the south structure and 50 cfs in the north structure to eliminate the cavitation.
* The pipeline design engineer was called to the site to observe the operating valves. Ultimately, the pipeline engineer consulted with the valve manufacturer and determined that the cavitation is likely not significant or catastrophic but should be monitored. Actions such as partially closing an upstream butterfly valve and opening both operating valves concurrently (i.e., delivering water through both structures and filling cells 1 and 3 at the same time) will reduce pressure across each operating valve, which could eliminate the cavitation issue. The EDO will continue to monitor the operating valves during future operations and will consult with the pipeline engineer to determine if future structural changes are needed at the outlets/valves.

## Water Control Structures & Berms

Water is controlled, contained, and ponded at the CWR BSR project via seven Rubicon water control structures (**Figure 2a**), one boarded water control structure and eight earthen berms (**Figure 2b**). The Rubicon gates can be controlled locally or remotely and can be set to 1) an inputted fixed position, 2) to self-regulate an inputted upstream water surface elevation or 3) to self-regulate an inputted maximum pass-through flow rate. The project was designed to fill upstream to downstream by setting the gates to self-regulate and maintain an inputted upstream water surface elevation. Water backs up behind the water control structures and berms to create the ponded areas in the eight cells. Important notes regarding performance of the water control structures and berms are presented below:



A

B

**Figure 2**: **(A)** Rubicon water control structure with water ponded on the upstream side of the gate and berm. **(B)** Earthen berm with water ponded on its upstream side (Cell 1 looking north/northeast from the water control structure).

* The water control structures performed well. All three control modes worked successfully. The control mode that will be used most frequently, which is self-regulating an inputted upstream water surface elevation, proved effective.
* However, even with the self-regulating settings on the structures, Program staff still need to monitor water levels, flow rates, cumulative volumes, etc. during the fills. This can be done remotely from a computer or cell phone. Gate self-adjustments are effective, but relatively slow in relation to the rate at which water surfaces rise when 50 to 75 cfs are being delivered, particularly in the upstream cells. This results in a significant volume of water being passed to downstream cells as the gates read water levels and self-adjust to the inputted elevations. This is not a flaw but needs to be planned for and monitored when overseeing fillings.
* There were no issues with the earthen berms during the fillings. The water ponded generally as expected. There were no breaches and no areas where the water circumvented the berms. Vegetation establishment was adequate and should continue to develop over the next several years. Berms will be monitored by Program staff before, during and after fillings.

## Miscellaneous

Other miscellaneous pieces of project infrastructure generally worked well:

* The local valve operator that is housed in the on-site control box was used to control and aggregate daily deliveries. The operator’s remote-control function was not tested because the necessary hardware was still being installed and tested by the CNPPID.
* The Rubicon gates’ remote-control and monitoring functions (i.e., the SCADA system) worked well.
* Additionally, there were no major issues with the project’s culverts, spillways, or toe-drain structures.
* A weather station installed onsite by the University of Nebraska-Lincoln collects temperature, precipitation, and other weather data. The station appears to be functioning well.

# Deliveries & Routing

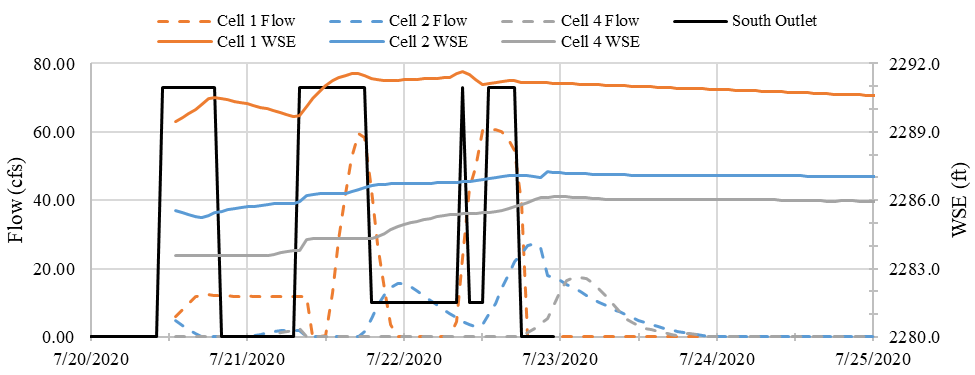
The CWR BSR project was filled three times from July to September. Dates and details for each of the test fills are shown in **Table 1**.

**Table 1**: Dates, target cells and delivery volumes for each of the three test fills.

|  |  |  |  |
| --- | --- | --- | --- |
| Fill # | Dates | Target Cells | Delivered Vol. [AF] |
| 1 | 7/20 – 22 | 1, 2, 4 | 152 |
| 2 | 8/17 – 18 | 5, 7 | 110 |
| 3 | 9/21 – 22 | 3, 6, 8 | 98 |

## Fill No. 1

Fill number 1 targeted cells 1, 2 and 4, and was completed over three days in July (**Table 1** and **Figure 3**). Deliveries were performed mostly during daylight hours to allow staff to be onsite because it was the first time the pipeline and other infrastructure were operated. Deliveries approached 75 cubic feet per second (cfs). Overnight, deliveries were either ceased (night of 7/21) or greatly reduced (night 7/22).



**Figure 3**: Delivery rates, water surface elevations and flow rates through the gates during fill #1.

The project was filled upstream to downstream (**Figure 3**). The total volumes delivered and passed through each cell are shown in **Table 2**. Delivery losses were significant over the three days as can be seen by comparing the volumes detained in each cell and the full pool volumes in **Table 2**. In addition, there was a significant attenuation in cell-to-cell delivery rates through the project. Approximately 75 cfs was delivered through the pipeline outlet (into cell 1), 60 cfs was delivered through gate 1 (into cell 2), and 28 cfs was delivered through gate 2 (into cell 4). The cells were not full (or near full) simultaneously until late Wednesday, 7/22 (**Figure 3**). For reference, the full pool elevations in cells 1, 2 and 4 are 2291.6 ft, 2287.2 ft and 2286.1 ft, respectively (**Table 2**). Post filling infiltration rates are calculated using a water balance approach in Section 3.4.

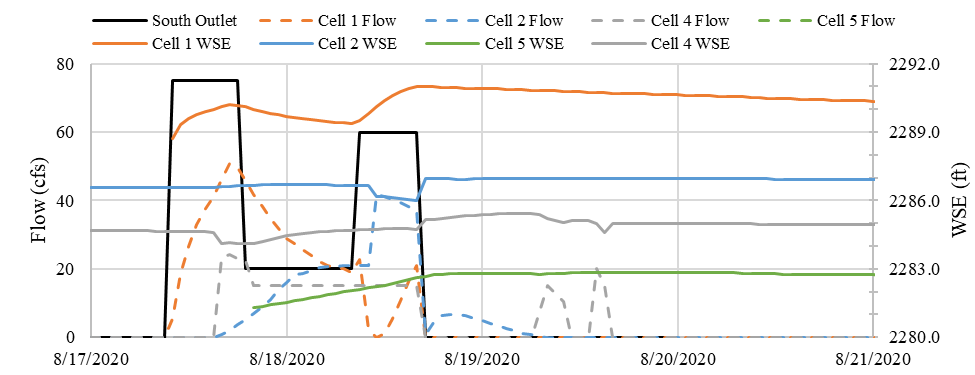
The losses and routing inefficiencies that caused the attenuation of delivery rates are not design or operational flaws; instead, they are the result of antecedent conditions and project characteristics. Specifically, significant initial infiltration losses were likely due to the wetting of large swaths of dry, upland ground. In addition, significant vegetation cover on the ground obstructed flow in some cells and kept water ponded in isolated areas away from the main pool and gate. This was likely the case in cell 2 where filling to the full pool elevation took an especially long time due to the absence of a low flow channel, its flat terrain and heavily vegetated areas. Vegetation management actions (i.e., grazing, burning, mowing, etc), which will occur semi-regularly, could help improve filling efficiencies but additional ponding is not unwelcome as it increases recharge volumes. The same would be true for activities like constructing a low flow channel to improve routing efficiency.

**Table 2**: Volumes delivered and passed through each cell during fill #1.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cell # | Full Pool Elev. [ft] | Full Pool Vol. [AF] | Delivered Vol. [AF] | Passed Vol. [AF] | Detained Vol. [AF] |
| 1 | 2291.6 | 44 | 152 | 90 | 62 |
| 2 | 2287.2 | 33 | 90 | 46 | 44 |
| 4 | 2286.1 | 20 | 46 | 16 | 30 |

## Fill No. 2

Fill number 2 targeted cells 5 and 7 and was completed over two days in August (**Table 1** and **Figure 4**). Deliveries were again performed mostly during working hours, but overnight deliveries were increased to 20 cfs (**Figure 4**). Deliveries approached 75 cubic feet per second (cfs) when the operating valve in the south delivery structure was turned to full open.



**Figure 4**: Delivery rates, water surface elevations and flow rates through the gates during fill #2.

Here, cells 1, 2 and 4 were used as flow through cells, which deviates from the intended normal operating conditions (**Figure 4**). The gates controlling water levels in cells 1, 2 and 4 remained full open. The total volumes delivered and passed through each cell are shown in **Table 3**. The attenuation that was observed in cell-to-cell delivery rates in July was observed in August. Approximately 75 cfs was delivered through the pipeline outlet (into cell 1), 50 cfs was delivered through gate 1 (into cell 2), 40 cfs was delivered through gate 2 (into cell 4) and 25 cfs was delivered through gate 4 (into cell 5) (**Figure 4**). Water began reaching the cell 5 gate late on Monday, 8/17. However, the maximum water surface elevation in cell 5 only approached 2283.0 ft. For reference, the full pool elevation in cell 5 is 2284.7 ft (**Table 2**). Post filling infiltration rates are calculated using a water balance approach in Section 3.4.

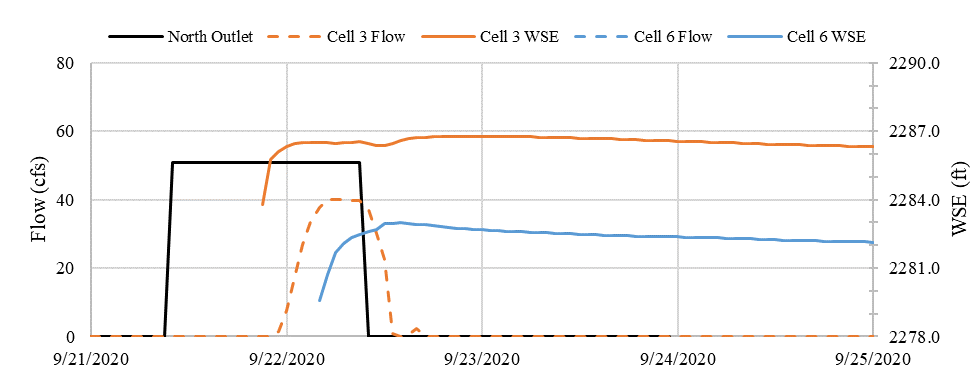
**Table 3**: Volumes delivered and passed through each cell during fill #2.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cell # | Full Pool Elev. [ft] | Full Pool Vol. [AF] | Delivered Vol. [AF] | Passed Vol. [AF] | Detained Vol. [AF] |
| 1 | 2291.6 | 44 | 110 | 65 | 45 |
| 2 | 2287.2 | 33 | 65 | 47 | 18 |
| 4 | 2286.1 | 20 | 47 | 40 | 7 |
| 5 | 2284.7 | 91 | 40 | <1 | 40 |

Deliveries were halted on Tuesday, 8/18 when it was realized that gate 4 was reporting erroneous flow values. Consequently, cell 5 was only partially filled and water was not delivered to cell 7. This was done out of an abundance of caution since deliveries to cell 5 could not be accurately monitored. The reported flow values for cell/gate 4 are estimated based on field measurements (**Figure 4**). The erroneous values were a result of backwater in cell 5 moving into cell 4 and there being a “drown out” of the sensors in the cell 4 gate: meaning flow through the flume could not be monitored by the sensors because a gradient did not exist between the gate’s upstream and downstream sensors. This will be addressed by filling cell 4 before making releases to cell 5, ensuring that a gradient exists by maximizing the water surface elevations in cell 4. Otherwise, the routing from the cell 4 gate to the cell 5 gate was efficient as there is a channel that deliveries water very near the cell 5 gate.

## Fill No. 3

Fill number 3 targeted cells 3, 6 and 8 and was completed over two days. Deliveries were sustained at slightly over 50 cfs for approximately 24 hrs (**Figure 5**). Deliveries during this fill most closely resemble intended operating conditions because water was delivered at a continuous rate and the self-regulating gates were relied upon to control water surface elevations.



**Figure 5:** Delivery rates, water surface elevations and flow rates through the gates during fill #3.

The cells were filled upstream to downstream (**Figure 5**). The total volumes delivered and passed through each cell are shown in **Table 4**. Delivery losses in cell 3 were significant over the 24-hour period as can be seen by comparing the volume detained in cell 1 and the cell 1 full pool volume in **Table 4**. Water took over 12 hours to reach the cell 3 gate, but the attenuation from the pipeline outlet to the cell 3 gate was only 10 cfs (from about 50 cfs to 40 cfs). Pipeline deliveries were ceased early on Tuesday, 9/22 when cell 3 and 6 were approaching full pool and approximately 100 acre-feet had been released from the pipeline. Deliveries were not adequate to fill cell 8. Post filling infiltration rates are calculated using a water balance approach in Section 3.4.

**Table 4**: Volumes delivered and passed through each cell during fill #3.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cell # | Full Pool Elev. [ft] | Full Pool Vol. [AF] | Delivered Vol. [AF] | Passed Vol. [AF] | Detained Vol. [AF] |
| 3 | 2287.2 | 37 | 98 | 34 | 64 |
| 6 | 2283.1 | 53 | 34 | 0 | 34 |

The initial losses in cell 3 were significant and likely due in large part to the extremely dry antecedent soil conditions. In addition, cell 3 is very flat and it takes water a long time to make it to the cell 3 gate (like cell 2). Once over the cell 3 gate, water moves almost directly to the cell 6 gate via a low flow channel. Water builds head on the cell 6 gate quickly. Consequently, water surface elevations at the cell 6 gate can likely be set slightly above full pool levels to let water adequately fill the cell. This contrasts with cells like 2 and 3, where quite a bit of water needs to be released before it starts to build head on the gate. It should also be noted that the inability to fill cell 8 is not expected to be a persistent problem. Cell 8 should be filled easily if enough water is delivered through the north discharge structure. The volume lost in cell 3 during this fill far exceeded expectations, resulting in a shortage in cell 8.

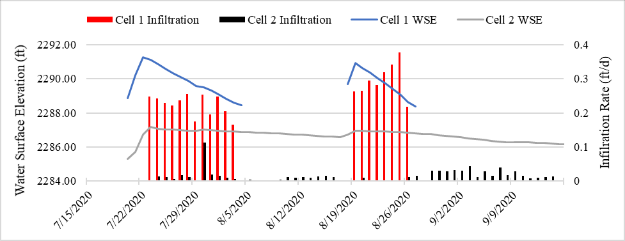
## Water Balance

A water balance approach is used for project accounting and to calculate infiltration rates in each of the cells.[[2]](#footnote-2) Infiltration rates are calculated in each cell using data collected at the water control structures and a nearby weather station.[[3]](#footnote-3) The data presented from these test fills are intended to be used to plan for future operations, and to estimate project-scale infiltration rates. Specifically, this and future data will be used to develop a dataset that informs operations and groundwater models that will be used for planning, accounting, and scoring purposes.

Average daily post-filling infiltration rates (i.e., daily infiltration rates beginning when the filling is complete) are summarized in **Table 5**. Average infiltration rates vary from close to 0.0 ft/day to nearly 0.3 ft/day due to both cell characteristics and fill characteristics. In general, cells that are comprised of mostly upland areas (e.g., cell 1) have higher average infiltration rates than those that are comprised of large low-lying wetland areas (e.g., cell 2). Specifically, **Figure 6** shows how differently cell 1 and cell 2 functioned after the fillings. Water infiltrated at a much higher rate in cell 1 than cell 2, which contains an existing wetland that is almost always ponded. Furthermore, cells appear to have higher infiltration rates when they are filled nearer their full pool elevations (e.g., cell 5 post fill 1 vs cell 5 post fill 2) (**Table 5**). This is because more upland areas are inundated when cells are filled to higher levels, and because there is a greater mass pushing water into the ground.

**Table 5**: Average infiltration rates post fills 1, 2 and 3.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Fill | Cell 1 [ft/d] | Cell 2 [ft/d] | Cell 3 [ft/d] | Cell 4 [ft/d] | Cell 5 [ft/d] | Cell 6 [ft/d] |
| 1 - (July) | 0.22 | 0.01 | - | 0.05 | 0.07 | - |
| 2- (Aug) | 0.29 | 0.02 | - | 0.01 | 0.11 | - |
| 3- (Sep) | - | - | 0.15 | - | - | 0.21 |



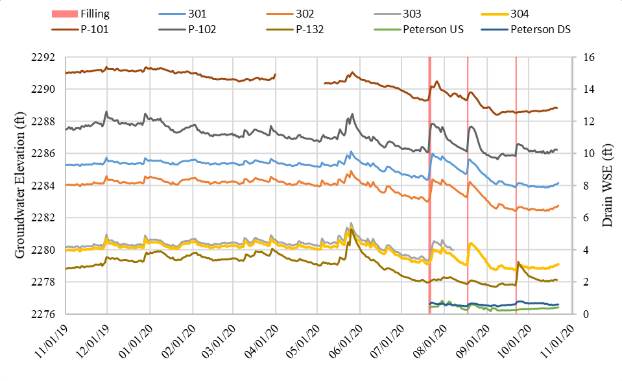
**Figure 6:** Water surface elevations in cell 1 and cell 2 plotted with daily infiltration rates.

# Local Monitoring

Several groundwater and surface water monitoring devices are installed in and near the CWR BSR project (well locations labeled in **Appendix A**). Groundwater is monitored in several wells around the site and surface water is monitored at two locations in the Peterson Ditch, which bisects the property. These are in addition to the Rubicon gates, which monitor and record water levels in the cells. Time series of surface and groundwater levels collected at these locations are used to develop a large dataset that can be monitored and analyzed by Program staff. Here, data from the wells is used to observe system-wide response to the filling activities in July, August and September, and data from the gates is used to calculate post-filling infiltration rates using a water balance approach.

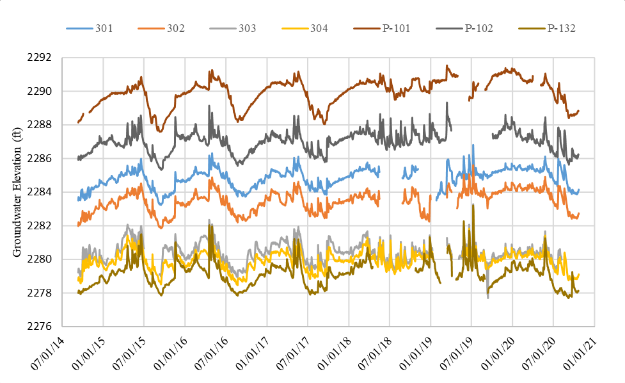
## Surface Water & Groundwater

Monitoring wells owned by the Program and the Tri-Basin Natural Resources District (TBNRD) are sited around the property. The Program owns wells 301, 302, 303 and 304, which were installed and equipped with data loggers in 2014. In addition, the Program owns the two data loggers in the Peterson Drain, which were installed and equipped with data loggers in July 2020 (immediately preceding the first fill in July). The TBNRD owns wells P-101, P-102 and P-132, which are located near the county roads around the property. The TBNRD wells have been collecting continuous data for over 10 years. Groundwater and surface water data from each of the wells is presented in **Figure 7**. Data is shown from November 2019 to November 2020. Groundwater elevations are plotted on the left y-axis and drain water surface elevations are presented on the right y-axis. Fillings are denoted using red shading in July, August and September of 2020.



**Figure 7:** Groundwater and surface water elevations collected in monitoring wells and drain monitoring locations. Time series shown is from 11/1/19 to 11/1/2020.

Groundwater elevations increased as a result of the July, August, and September fillings. Groundwater elevations increased by up to 2 feet when cells containing the wells or cells very near the wells were filled (e.g., well 301 and 302 during fills 1 and 2). More subtle increases were observed in wells that were further from the fillings (e.g., well P-132 during fills 1 and 2). In general, these responses were relatively subtle. The groundwater elevations began decreasing immediately and were generally back to near pre-fill levels after approximately 2 weeks to 1 month. This suggests that water moves through the alluvial system relatively quickly and efficiently, which is not surprising because the alluvium is comprised of mostly clean sand. The fills did not appear to affect the seasonal downward trend in groundwater levels that is typical of the late summer and early fall. For comparison to historical levels, **Figure 8** shows groundwater levels from 2014 to the present.



**Figure 8:** Groundwater and surface water elevations collected in monitoring wells and drain monitoring locations. Time series shown is from 11/1/19 to 11/1/2020.

# Conclusions and Takeaways

The main conclusions and takeaways from this report are summarized below:

1. The major pieces of project infrastructure performed well during the test fills. An issue that will need to be monitored closely is the suspected beginning-level cavitation on or near the pipeline valves at each discharge structure. Currently, no structural improvements are planned. It is expected that filling cells 1 and 3 concurrently will improve conditions.
2. The Rubicon gates and associated remote control and monitoring systems work well and greatly reduce on-site staff time during and after operations. However, regardless of the self-regulating feature, the gates do require regular monitoring during fills to ensure that the gates are acting as expected, and to track deliveries to and from each cell.
3. Low flow channels in cells 2 and 3 could help filling efficiencies. Right now, a large volume of water needs to be delivered to each cell before head is built up on the Rubicon gates due to thick vegetation and extremely flat terrain in these two cells. Theoretically, it would be easy to over-fill the cells if attention is only being paid to water levels at the gate. However, this is not totally unwelcome because it also likely increases saturation, ponding, and infiltration. This issue will be monitored and the need for a low flow channel will be assessed moving forward. Construction on such a feature is not imminent.
4. Filling of cells 7 and 8 during the August and September fills, respectively, was desired but not achieved. This is not a concern moving forward. Operations in 2020 were conservative because it was the first time the project has been tested, and it is believed that those cells would have been filled easily if more water had been delivered to the project.
5. Recharge operations resulted in increases in both groundwater and surface water elevations in the area. Increases were only about 2 ft when filling cells very near the wells and less when filling cells several hundred or thousand feet away from the wells. Water surface elevations in the Peterson Drain increased subtly (i.e., a few inches). Groundwater and surface water will continue to be monitored in the area. The Program may install an additional well downstream of the project to increase regional monitoring capabilities.
6. The Program will continue with full operations in 2021. The project will be filled with excesses in the Platte River, when available. The Program will be ready for deliveries in the late spring or early summer, after icing concerns have passed. The objective in 2021 will be to continue to optimize project operations and to collect the data necessary to inform future operation and scoring models.

# APPENDIX A: SITE MAP

1. Executive Director’s Office (EDO), Platte River Recovery Implementation Program. *Cottonwood Ranch Broad-Scale Recharge: Project Information, Monitoring, Operations and Maintenance Document*, Version 1.0, June 30, 2020. [↑](#footnote-ref-1)
2. Executive Director’s Office (EDO), Platte River Recovery Implementation Program. *Cottonwood Ranch Broad-Scale Recharge: Project Information, Monitoring, Operations and Maintenance Document*, Version 1.0, June 30, 2020. [↑](#footnote-ref-2)
3. Data from the High Plains Regional Climate Center (HPRCC) was used here to estimate precipitation and evapotranspiration at the site. Data from a station in Holdrege, Nebraska was used for this analysis. However, a on-site weather station exists and will be used in the future. [↑](#footnote-ref-3)