Amended 9/25/2023

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.545 & 537.765 and OAR 690-205-0210)

MORR 52902
8/16/2023

WELL I.D. LABEL# L 149026
START CARD # 1057608
ORIGINAL LOG #

(1) LAND OWNER
Owner Well I.D.
First Name   Last Name
Company CITY OF BOARDMAN
Address 200 CITY CENTER CIRCLE
City BOARDMAN State OR Zip 97818

(2) TYPE OF WORK
[X] New Well [ ] Deepening [ ] Conversion
[ ] Alteration (complete 2a & 10) [ ] Abandonment(complete 5a)

(2a) PRE-ALTERATION

	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd
Casing:									

	Material	From	To	Amt	sacks/lbs
Seal:					

(3) DRILL METHOD
[X] Rotary Air [ ] Rotary Mud [ ] Cable [ ] Auger [ ] Cable Mud
[ ] Reverse Rotary [X] Other CLAMSHELL/HORZ-DRIL

(4) PROPOSED USE
[ ] Domestic [ ] Irrigation [X] Community
[ ] Industrial/ Commercial [ ] Livestock [ ] Dewatering
[ ] Thermal [ ] Injection [X] Other RANNEY COLLECTOR WELL

(5) BORE HOLE CONSTRUCTION
Special Standard [X] (Attach copy)
Depth of Completed Well 51.50 ft.

BORE HOLE

Dia	From	To
234	0	51.5

SEAL

Material	From	To	Amt	sacks/lbs
Cement	0	19	1500	S
		Calculated	1616	
		Calculated		

Seal placement method [ ] A [ ] B [ ] C [ ] D [ ] E [X] Other: see attached docs.
Backfill placed from ft. to ft. Material
Filter pack from ft. to ft. Material Size
Explosives used: [ ] Type Amount
Seal Placement Begin Date 11/30/2022 Begin Time 08 00

(5a) ABANDONMENT USING UNHYDRATED BENTONITE
Proposed Amount   Actual Amount

(6) CASING/LINER

Casing	Liner	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd
X		228	X	2	51.5	3 ft.				

Shoe [ ] Inside [ ] Outside [X] Other Location of shoe(s) 51.5
Temp casing [ ] Yes Dia From + [ ] To

(7) PERFORATIONS/SCREENS
Perforations Method
Screens Type Material

Perf/ Screen	Casing/ Liner	Screen Dia	From	To	Scrn/slot width	Slot length	# of slots	Tele/ pipe size

(8) WELL TESTS: Minimum testing time is 1 hour
(●) Pump ( ) Bailer ( ) Air ( ) Flowing Artesian

Yield gal/min	Drawdown	Drill stem/Pump depth	Duration (hr)
5945	22	44	72

Temperature 57 °F Lab analysis [ ] Yes By
Water quality concerns? [ ] Yes (describe below) TDS amount 153 mg/L

From	To	Description	Amount	Units
43	44	Iron	0.07	mg/L
43	44	Turbidity	7	ppm
43	44	Total Disolved Solids	153	mg/L

(9) LOCATION OF WELL (legal description)
County MORROW Twp 4.00 N N/S Range 25.00 E E/W WM
Sec 9 NW 1/4 of the NW 1/4 Tax Lot 102
Tax Map Number   Lot
Lat ° ' " or 45.84778056 DMS or DD
Long ° ' " or -119.70090556 DMS or DD
( ) Street address of well (●) Nearest address
OFF MARINE DRIVE NE BOARDMAN OREGON 97818 AT SAILBOARD BEACH

(10) STATIC WATER LEVEL

	Date	SWL(psi)	+	SWL(ft)
Existing Well / Pre-Alteration				
Completed Well	4/25/2023			7

Flowing Artesian? [ ] Dry Hole? [ ]

WATER BEARING ZONES   Depth water was first found 7.00

SWL Date	From	To	Est Flow	SWL(psi)	+	SWL(ft)
4/25/2023	7	44	6000			7

(11) WELL LOG
Ground Elevation

Material	From	To
TOP SOIL SAND LIGHT BRWN	0	7
SAND BRWN COBBLES WTR	7	15
COBBLES GRAVEL LARGE COURSE SAND WT	15	51.5

Construction Begin Date 9/15/2022 Begin Time 00 00 End Date 4/25/2023

(unbonded) Water Well Constructor Certification
I certify that the work I performed on the construction, deepening, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
License Number   Date
Signed

(bonded) Water Well Constructor Certification
I accept responsibility for the construction, deepening, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
License Number 1962 Date 8/16/2023
Signed STEVE KASER (E-filed)
Contact Info (optional) STEVE KASER WWC 1962

WATER SUPPLY WELL REPORT - continuation page

MORR 52902

8/16/2023

WELL I.D. LABEL# L 149026

START CARD # 1057608

ORIGINAL LOG #

(2a) PRE-ALTERATION

Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd

Material	From	To	Amt	sacks/lbs

(5) BORE HOLE CONSTRUCTION

BORE HOLE

Dia	From	To

SEAL

Material	From	To	Amt	sacks/lbs
		Calculated		
		Calculated		
		Calculated		
		Calculated		

FILTER PACK

From	To	Material	Size

(6) CASING/LINER

Casing Liner	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd

(7) PERFORATIONS/SCREENS

Perf/ Screen	Casing/ Liner	Screen Dia	From	To	Scrn/slot width	Slot length	# of slots	Tele/ pipe size

(8) WELL TESTS: Minimum testing time is 1 hour

Yield gal/min	Drawdown	Drill stem/Pump depth	Duration (hr)

Water Quality Concerns

From	To	Description	Amount	Units
43	44	HARDNESS	110	mg/L
43	44	Bacterial	6.3	MPN/1
43	44	PH	8	S.U.
43	44	ORGANIC CARBON LEVEL	1.53	mg/L

(10) STATIC WATER LEVEL

SWL Date	From	To	Est Flow	SWL(psi)	+	SWL(ft)

(11) WELL LOG

Material	From	To

Name of person(s) who assisted with construction and Trainee License # / Helper #

Assistant Name	Type	#

Comments/Remarks

Well sealed using sixteen 2-inch grouting pipes evenly spaced around caissons to pressure grout cement. Casing is 3-foot diameter concrete caissons.

WATER SUPPLY WELL REPORT - Map with location identified must be attached and shall include an approximate scale and north arrow

MORR 52902

8/16/2023

Map of Hole

STATE OF OREGON
WELL LOCATION MAP

This map is supplemental to the WATER SUPPLY WELL REPORT

Oregon Water Resources Department
725 Summer St NE, Salem OR 97301
(503)986-0900

LOCATION OF WELL

Latitude: 45.84778056 Datum: WGS84

Longitude: -119.70090556

Township/Range/Section/Quarter-Quarter Section:
WM4.00N25.00E9NWNW

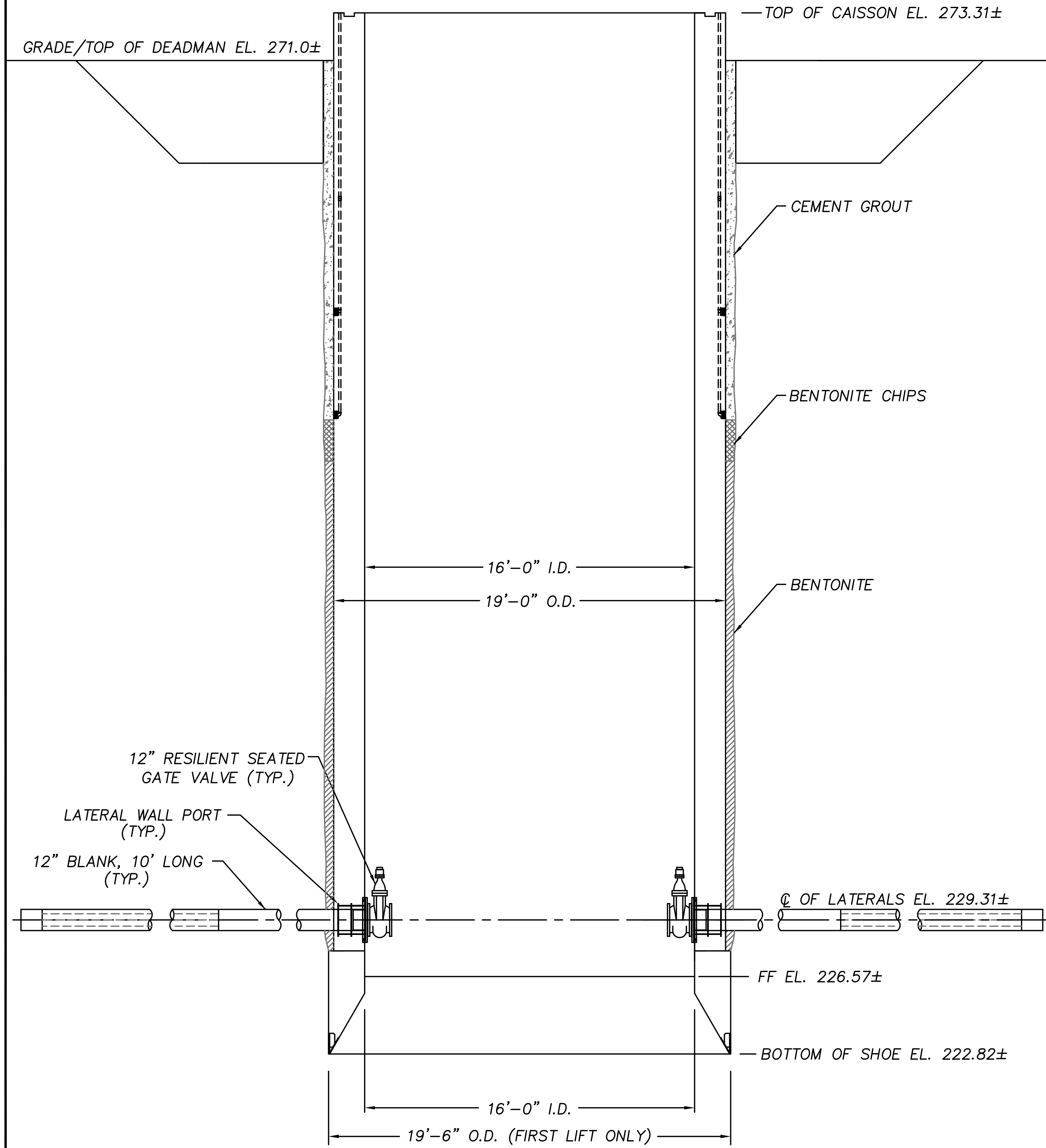
Address of Well:
OFF MARINE DRIVE NE BOARDMAN OREGON 97818 AT SAILBOARD BEACH

Well Label: 149026

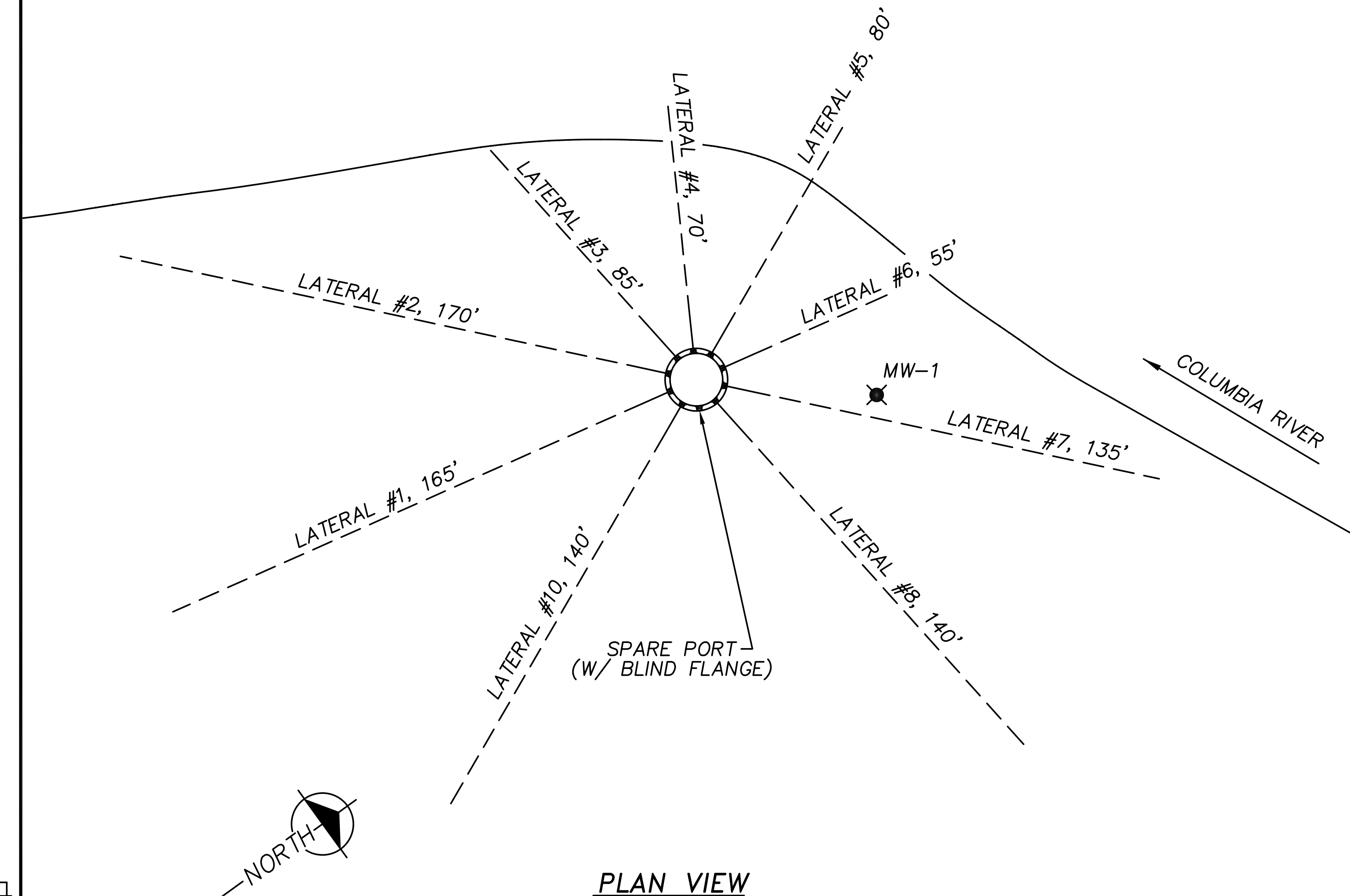
Printed: August 16, 2023

DISCLAIMER: This map is intended to represent the approximate location the well. It is not intended to be construed as survey accurate in any manner.

Provided by well constructor



VERTICAL SECTION THRU CAISSON
SCALE: N.T.S.



PLAN VIEW
SCALE: 1"=50'

Layne
A GRANITE COMPANY
RANNEY COLLECTOR WELLS
6360 HUNTLEY ROAD
COLUMBUS, OHIO 43229
(614) 888-6263 / FAX (614) 888-9208

COLLECTOR WELL SECTION and PLAN VIEW
CITY OF BOARDMAN, OREGON
WATER SYSTEMS IMPROVEMENTS – PHASE 1
COLLECTOR WELL NO. #3

FILE NAME: 1145524–08	DATE: 6/28/23	FIGURE 2.0
PROJECT #: 1145524	SCALE: AS NOTED	

Collector Well
Recommended Screen Slot Distribution

Client:	City of Boardman, Oregon
Well ID:	Collector Well No. 3
Lateral Number:	1
Lateral Length:	165 feet
Screen Length:	155 feet
Date Submitted:	3/22/2023

Screen slot distribution		
Distance from Inside Wall of Caisson (feet)	Screen Slot Size (1000^{ths} inch)	
0-10	Blank	
10-20	30	slot
20-30	30	slot
30-40	50	slot
40-50	80	slot
50-60	60	slot
60-70	100	slot
70-80	120	slot
80-90	150	slot
90-100	150	slot
100-110	100	slot
110-120	60	slot
120-130	100	slot
130-140	80	slot
140-150	60	slot
150-160	80	slot
160-165	100	slot

5 footer

Screen Size Utilization		
Screen Slot Size (1000^{ths} inch)	Number of 10-foot Section	Length per Slot Size (feet)
Blank	1	10
10	0	0
20	0	0
30	2	20
40	0	0
50	1	10
60	3	30
80	3	30
100	3	30
100	1	5
120	1	10
125	0	0
150	2	20
Total	17	165

Collector Well
Recommended Screen Slot Distribution

Client:	City of Boardman, Oregon
Well ID:	Collector Well No. 3
Lateral Number:	2
Lateral Length:	170 feet
Screen Length:	160 feet
Date Submitted:	3/31/2023

Screen slot distribution		
Distance from Inside Wall of Caisson (feet)	Screen Slot Size (1000ths inch)	
0-10	Blank	
10-20	20	slot
20-30	20	slot
30-40	20	slot
40-50	20	slot
50-60	30	slot
60-70	40	slot
70-80	40	slot
80-90	30	slot
90-100	30	slot
100-110	30	slot
110-120	20	slot
120-130	20	slot
130-140	20	slot
140-150	30	slot
150-160	40	slot
160-170	20	slot

Screen Size Utilization		
Screen Slot Size (1000ths inch)	Number of 10-foot Section	Length per Slot Size (feet)
Blank	1	10
10	0	0
20	8	80
30	5	50
40	3	30
50	0	0
60	0	0
80	0	0
100	0	0
120	0	0
125	0	0
150	0	0
Total	17	170

Collector Well
Recommended Screen Slot Distribution

Client:	City of Boardman, Oregon
Well ID:	Collector Well No. 3
Lateral Number:	3
Lateral Length:	85 feet
Screen Length:	75 feet
Date Submitted:	4/12/2023

Screen slot distribution

Distance from Inside Wall of Caisson (feet)	Screen Slot Size (1000ths inch)		
0-10	Blank		
10-20	20	slot	
20-30	10	slot	
30-40	20	slot	
40-50	30	slot	
50-60	30	slot	
60-65	80	slot	5 Footer
65-75	125	slot	
75-85	150	slot	

Screen Size Utilization

Screen Slot Size (1000ths inch)	Number of 10-foot Section	Length per Slot Size (feet)
Blank	1	10
10	1	10
20	2	20
30	2	20
40	0	0
50	0	0
60	0	0
80	1	5
100	0	0
120	0	0
125	1	10
150	1	10
Total	9	85

Collector Well
Recommended Screen Slot Distribution

Client:	City of Boardman, Oregon
Well ID:	Collector Well No. 3
Lateral Number:	4
Lateral Length:	70 feet
Screen Length:	60 feet
Date Submitted:	4/7/2023

Screen slot distribution		
Distance from Inside Wall of Caisson (feet)	Screen Slot Size (1000^{ths} inch)	
0-10	Blank	
10-20	20	slot
20-30	20	slot
30-40	50	slot
40-50	100	slot
50-60	150	slot
60-70	150	slot

Screen Size Utilization		
Screen Slot Size (1000^{ths} inch)	Number of 10-foot Section	Length per Slot Size (feet)
Blank	1	10
10	0	0
20	2	20
30	0	0
40	0	0
50	1	10
60	0	0
80	0	0
100	1	10
120	0	0
125	0	0
150	2	20
Total	7	70

Collector Well
Recommended Screen Slot Distribution

Client:	City of Boardman, Oregon
Well ID:	Collector Well No. 3
Lateral Number:	5
Lateral Length:	80 feet
Screen Length:	70 feet
Date Submitted:	2/26/2023

Screen slot distribution		
Distance from Inside Wall of Caisson (feet)	Screen Slot Size (1000^{ths} inch)	
0-10	Blank	
10-20	80	slot
20-30	80	slot
30-40	80	slot
40-50	120	slot
50-60	150	slot
60-70	120	slot
70-80	80	slot

Screen Size Utilization		
Screen Slot Size (1000^{ths} inch)	Number of 10-foot Section	Length per Slot Size (feet)
Blank	1	10
10	0	0
20	0	0
30	0	0
40	0	0
50	0	0
60	0	0
80	4	40
100	0	0
120	2	20
150	1	10
Total	8	80

Collector Well
Recommended Screen Slot Distribution

Client:	City of Boardman, Oregon
Well ID:	Collector Well No. 3
Lateral Number:	6
Lateral Length:	55 feet
Screen Length:	45 feet
Date Submitted:	2/2/2023

Screen slot distribution

Distance from Inside Wall of Caisson (feet)	Screen Slot Size (1000^{ths} inch)		
0-10	Blank		
10-20	100	slot	
20-30	80	slot	
30-40	125	slot	
40-50	125	slot	
50-55	100	slot	5 footer

Screen Size Utilization

Screen Slot Size (1000^{ths} inch)	Number of 10-foot Section	Length per Slot Size (feet)
Blank	1	10
10	0	0
20	0	0
30	0	0
40	0	0
50	0	0
60	0	0
80	1	10
100	1	10
100	1	5
125	2	20
150	0	0
Total	6	55

Collector Well
Recommended Screen Slot Distribution

Client:	City of Boardman, Oregon
Well ID:	Collector Well No. 3
Lateral Number:	7
Lateral Length:	135 feet
Screen Length:	125 feet
Date Submitted:	3/3/2023

Screen slot distribution			
Distance from Inside Wall of Caisson (feet)	Screen Slot Size (1000^{ths} inch)		
0-10	Blank		
10-20	150	slot	
20-30	125	slot	
30-40	100	slot	
40-50	80	slot	
50-60	40	slot	
60-70	80	slot	
70-80	100	slot	
80-90	100	slot	
90-100	60	slot	
100-110	40	slot	
110-120	60	slot	
120-130	125	slot	
130-135	150	slot	5 footer

Screen Size Utilization		
Screen Slot Size (1000^{ths} inch)	Number of 10-foot Section	Length per Slot Size (feet)
Blank	1	10
10	0	0
20	0	0
30	0	0
40	2	20
50	0	0
60	2	20
80	2	20
100	3	30
120	0	0
125	2	20
150	1.5	15
Total	13.5	135

Collector Well
Recommended Screen Slot Distribution

Client:	City of Boardman, Oregon
Well ID:	Collector Well No. 3
Lateral Number:	8
Lateral Length:	140 feet
Screen Length:	130 feet
Date Submitted:	3/9/2023

Screen slot distribution		
Distance from Inside Wall of Caisson (feet)	Screen Slot Size (1000^{ths} inch)	
0-10	Blank	
10-20	40	slot
20-30	30	slot
30-40	20	slot
40-50	20	slot
50-60	20	slot
60-70	20	slot
70-80	20	slot
80-90	20	slot
90-100	30	slot
100-110	40	slot
110-120	150	slot
120-130	150	slot
130-140	125	slot

Screen Size Utilization		
Screen Slot Size (1000^{ths} inch)	Number of 10-foot Section	Length per Slot Size (feet)
Blank	1	10
10	0	0
20	6	60
30	2	20
40	2	20
50	0	0
60	0	0
80	0	0
100	0	0
120	0	0
125	1	10
150	2	20
Total	14	140

Collector Well
Recommended Screen Slot Distribution

Client:	City of Boardman, Oregon	
Well ID:	Collector Well No. 3	
Lateral Number:	10	
Lateral Length:	140	feet
Screen Length:	130	feet
Date Submitted:	4/26/2023	

Screen slot distribution		
Distance from Inside Wall of Caisson (feet)	Screen Slot Size (1000^{ths} inch)	
0-10	Blank	
10-20	20	slot
20-30	20	slot
30-40	20	slot
40-50	80	slot
50-60	125	slot
60-70	150	slot
70-80	125	slot
80-90	50	slot
90-100	20	slot
100-110	20	slot
110-120	40	slot
120-130	80	slot
130-140	125	slot

Screen Size Utilization		
Screen Slot Size (1000^{ths} inch)	Number of 10-foot Section	Length per Slot Size (feet)
Blank	1	10
10	0	0
20	5	50
30	0	0
40	1	10
50	1	10
60	0	0
80	2	20
100	0	0
120	0	0
125	3	30
150	1	10
Total	14	140

3 PERFORMANCE TESTING FIELD PROCEDURES

3.1 GENERAL TESTING PROCEDURES

All testing was conducted under the supervision of an experienced Ranney hydrogeologist, and consisted of the following:

- A background water level monitoring period.
- An 8-hour multiple-rate step drawdown test.
- A recovery period.
- A 72-hour constant-rate pumping test.
- A 24-hour recovery period.

The pumping tests were conducted on the completed CW3 to determine its installed capacity and efficiency. Actual testing proceeded in two phases, with the first portion of the test pumping involving an 8-hour multiple-rate step test, conducted in steps of approximately two hours in duration at increasing rates of discharge. The step test was evaluated to determine the relative efficiency of the pumping well, confirm the proper operation of all equipment and wells, and determine the discharge rate for the subsequent constant-rate test. The constant-rate test results were used to evaluate the long-term yield of Collector Well No. 3under varying conditions.

One (1) temporary line-shaft turbine (Goulds & Johnson) and one (1) submersible pump (Gorman Rupp) were installed for the performance testing. The pumps were plumbed into two separate valved discharge lines, with the pumping rate for each pump being determined by two inline flow meters (equipped with an instantaneous readout and totalizer). The pumped discharge was conveyed to the Columbia River to prevent recirculation.

For the CW3 performance testing, the points that were monitored during the testing period included the following:

- Collector Well No. 3
- Observation Well MW1
- Columbia River

The approximate locations of the observation point are shown in Figure 3.1.0. Water levels were measured using direct read electric water level tapes with measurements made to the nearest 0.01 foot. Water levels were also automatically recorded in the CW3 caisson, MW1, and staff gauge using computerized data acquisition units and transducers manufactured by Insitu, Inc. The stage of the Columbia River was monitored with a temporary staff gauge (equipped with a transducer) that was installed at the CW3 Site. The measuring point for the staff gauge was surveyed during testing to provide reference point elevations. The base point/benchmark for the survey was the elevation (273.31 feet the of top of the caisson.

3.2 MULTIPLE-RATE STEP TEST PROCEDURES

Following a background water level monitoring period of approximately 18 hours, the multiple-rate step drawdown test was conducted on May 19, 2023. The eight (8) hour test was conducted in two-hour steps at increasing rates of discharge listed below:

Step	Rate (gallons per minute)	Duration (hours)
1	1,962	2
2	3,508	2
3	4,992	2
4	6,490	2

Before, during, and following the multiple-rate test, water levels and flow rates were measured at the pertinent frequencies in both CW3 and MW1 wells. The water level data logging units recorded water levels at 1-minute intervals during the multiple-rate test pumping and recovery periods. Manual water level and pumping data collected during the background period, multiple-rate step test, and recovery period are included in Appendix B, with the water level logging units' data included on the attached USB Flash Drive (rear of report).

During the multiple-rate test, sand content testing was conducted on the discharge water using a Rossum Sand Tester manufactured by the Roscoe Moss Company. After the first hour of the first step through the end of the last step of the multiple-rate step test, the sand volume in the sand tester sample tube was observed and recorded.

Approximately one (1) hour before the end of the last step of the multiple-rate test, a commercial dive team from Associated Underwater Services conducted the lateral flow analyses. The flow velocity and water temperature at the caisson end of each lateral were measured by the diver using handheld meters, which were remotely read by the hydrogeologist. The flow velocity measurements and the total pumping rate from the collector were used to determine the flow rate and percent of total flow from each lateral and the average lateral flow rate expressed as gallons per minute per foot of screen.

3.3 CONSTANT-RATE TEST PROCEDURES

Following the end of the pumping period for the multiple-rate test, water levels in CW3 were allowed to recover for more than 14 hours before starting the 72 hours constant-rate pumping test on May 20, 2023, at 08:15 AM. During the constant-rate test pumping period, the discharge from CW3 was maintained at an average rate of 5,945 gpm (8.6 MGD). After the test, the pump was shut off and the recovery of water levels was monitored for 24 hours.

As with the multiple-rate test, before, during, and following the constant-rate test, flow rates were intermittently measured in CW3, and water levels were also measured at pertinent frequencies both in CW3 and MW1. The water level data logging units recorded water levels at 1-minute intervals during the constant-rate test pumping and recovery periods. It should be noted that, only the temporary line-shaft turbine (Goulds & Johnson) pump was engaged during the constant rate testing.

As was done during the multiple-rate test, sand content testing was conducted during the constant-rate test on the discharge water. During the constant-rate test, the sand volume in the sand tester sample tubes was closely monitored and recorded. The following times represent Ranney's key elapsed pumping monitoring times:

1. 1 hour from the start of pumping
2. 24 hours from the start of pumping
3. 48 hours from the start of pumping
4. 72 hours from the start of pumping

Following the completion of performance testing, all discharge lines and temporary pumps were left in place for further short-duration sand testing after the post-performance testing lateral redevelopments.

4 PERFORMANCE TESTING RESULTS

4.1 BACKGROUND PERIOD

Background data collection for the Collector Well No. 3 performance testing began on May 18, 2023, when water level data recorders were installed in CW3, MW1, and Columbia River. Figure 4.1.0 presents hydrographs at the CW3 Site during the background and complete testing period. Typically, groundwater elevations in any given aquifer are influenced by the stage of an adjacent river. Figure 4.1.0 depicts the stage of the Columbia River showing little to no variation in elevation during the testing period. Groundwater elevation in CW3 and MW1 were slightly above the nearby Columbia River Elevation during the background period.

As can be seen in Figure 4.1.0, during the background monitoring period groundwater elevations were lower than the elevation of surface water in the Columbia River. At the start of the background monitoring period, the surface elevation of the Columbia River at the on-site staff gauge was 269.19 feet. There was period of high wind of over 25 miles per hour blowing from north to south that began approximately 39 hours into the constant rate test. That same period shows relatively rapid river elevation. The wind lasted through the end of the test. During the wind event, the Columbia River level crested and troughed at 269.82 and 268.66 feet respectively. The Columbia River level returned to baseline at the end of all testing and stabilized at 269.67 after 24 hours of the recovery period.

4.2 MULTIPLE-RATE TEST RESULTS

The multiple-rate step test was started on May 19, 2023, at 9:29 AM and concluded on May 19, 2023 at 5:30 PM. The individual pumping rates for the four (4) steps were 1,962 gpm, 3,508 gpm, 4,992 gpm, and 6,490 gpm. A summary of the multiple-rate test results is given in Table 4.2.0. Hydrographs of the observed water levels in CW3 and MW1 during the multiple-rate testing period are shown in Figure 4.2.0. A semi-logarithmic plot showing the time-drawdown relationship in CW3 is presented in Figure 4.2.1. Manual water level and pumping data collected during the multiple-rate step test and recovery period are included in Appendix B, with the water level recorder data being included on the attached USB flash drive (rear of report).

Before the multiple-rate test, all the lateral valves in the caisson were fully opened by the Associates Underwater Services diving team. With the pumping rates varying from 1,962 gpm to 6,490 gpm, the observed 2-hour specific capacity values varied from 600 gallons per minute per foot (gpm/ft) to 444 gpm/ft. Analysis of the multiple-rate testing was performed using the method described in Driscoll (1995) and Bruin and Hudson (1955). These methods are used to determine the head losses attributed to laminar flow in the aquifer and turbulent flow into the well. These head losses are related to the equation:

$$s = (B \times Q) + (C \times Q^2)$$

Where:

s = drawdown in the pumping well in feet
B = the aquifer constant (laminar flow) in feet/gpm
C = the well loss constant (turbulent flow) in feet/gpm^2

Q = the pumping rate in gpm

As shown in Table 4.2.0, laminar flow through the aquifer represents 94% of the head loss at a pumping rate of 1,962 gpm, declining to 75% at 6,490 gpm. The low percentage of drawdown attributed to turbulent well losses indicates the collector well operates efficiently.

4.3 CONSTANT-RATE TEST RESULTS

The constant-rate test pumping period was started on May 20, 2023, at 8:15 AM and ended at 8:15 AM on May 23, 2023 for an elapsed pumping time of 72 hours. Manual water level and pumping data collected during the constant-rate test and recovery period are included in Appendix B, with the water level recorder data being included on the attached USB flash drive (rear of report).

Figure 4.3.0 depicts hydrographs of the observed water levels for CW3 and MW1 during the constant-rate test, with the observed water levels and water level changes being summarized in Table 4.3.0. Figure 4.3.1 presents semi-log plots of the observed drawdown for CW3 and MW1 during the constant-rate test.

The step-drawdown test results indicated that the constant-rate test could be run at a rate of 6,000 gpm (8.6 MGD), which is the target yield of the well design. The average pumping rate during the 72 hours test was 5945 gpm. The observed drawdown in the CW3 after pumping at this rate for 72 hours was 22.0 feet, giving an observed specific capacity of 270 gpm/ft. At the end of the constant-rate test, the observed drawdown in the observation well was 21.7 feet.

As earlier stated, the Columbia River Stage was fairly stable prior to, during, and after the tests. The river stage varied approximately by 0.5 feet in elevation throughout the testing period. Therefore, there was no correction applied to the collected water level data to address changes in the river elevation. The Collector Well No. 3 and the observation well MW1 water levels were seen to be continuously declining at a slow rate at the end of 72 hours of pumping. This is an indication that the groundwater levels did not stabilize with respect to the river levels by the end of the constant-rate test, and that equilibrium between the amount of pumping and the amount of water recharging the aquifer from induced infiltration of river water was not achieved.

An estimate of the time at which equilibrium would have been reached between the pumping and the induced infiltration from the river can be computed using the following equation developed by Foley, Walton, and Dresher (1953):

$$t_e = \frac{a^2 S}{112 \cdot T \cdot \varepsilon_e \log\left[\left(\frac{2a}{r}\right)^2\right]}$$

Where:

t_e = Time to equilibrium (years)
a = Effective distance to the recharge boundary (feet)
r = Distance from the pumped well to the observation point (feet)

S = Aquifer Storage Coefficient (unitless)
T = Aquifer Transmissivity (gallons per day per foot (gpd/ft))
$\mathcal{E}_e$= Deviation from absolute equilibrium (arbitrarily assumed to be 0.05)

The following values were used in the above equation to estimate the time that equilibrium conditions would have been achieved:

- Effective distance to the recharge boundary = 500 feet
- Distance to the observation point = 92 feet (the average lateral length)
- Aquifer Storage Coefficient = 0.15 (for unconfined conditions)
- Aquifer Transmissivity = 102,590 gpd/ft (for a water temperature of 55^{o} F)
- Aquifer Transmissivity was calculated using the hydraulic conductivity from Layne, 1998 report and the as-built CW3 aquifer thickness

The values for effective distance to recharge and aquifer storage coefficient were chosen to provide a conservative estimate of the time to equilibrium. Utilizing the values above the estimated time to equilibrium is computed to be 11.5 days. Projecting the time drawdown trend for the CW3 from the latter part of the constant-rate test data to an elapsed pumping time of 11.5 days gives an estimated stabilized drawdown of 30.5 feet (or an elevation of approximately 238.9 feet). At the pumping rate of 5,945 gpm, the specific capacity for the estimated stabilized drawdown is 195 gpm/ft. It should be noted that the 238.9 feet elevation value of time to equilibrium of 11.5 days is 0.4 feet lower than the recommended minimum pumping level elevation of 239.3 feet.

4.4 LATERAL FLOW ANALYSIS RESULTS

Approximately one (1) hour before the end of the last step of the multiple-rate test, personnel from Associated Underwater Services entered the well and collected data to evaluate relative lateral flow and water temperatures. Table 4.4.0 presents the results of the lateral flow analysis. During the multiple-rate pumping test, the individual laterals produced between 3% to 17% of the total flow, with flow rates ranging from 4.9 to 9.7 gpm per foot of screen. The lowest flow was from Lateral 6, the highest flow was from Lateral 1, and these laterals have a screen length of 45 and 155 feet respectively. In general, the shorter lateral contributed a lower percentage of the overall flow than the longer laterals.

The water temperature from the individual laterals ranged from 51.8^{o} F to 57.6^{o} F. The highest temperatures were from Lateral 1, 8, and Lateral 10, which are installed landwards and away from the Columbia River. The temperature of the river at the staff gauge was 57.1° F during the multiple-rate step test.

4.5 SAND CONTENT TESTING

Sand content testing was conducted during the multiple-rate and constant-rate tests. The sand testing results are presented in Table 4.5.0. The specified maximum acceptable average sand content for all measurements during the multiple-rate step test and constant-rate tests was 2 ppm. The fourth step of the multiple-rate step test did not meet the sand testing requirement of 2 ppm.

For the 72-hour constant-rate sand testing, the sand content testing was conducted from the first hour of pumping through the end of the 72-hour constant-rate testing. The result from Table 2 shows that the sand content in CW3 started slightly above the specified target of 2 ppm. The sand content slowly drops between the 1st hour and the 45th hour of the sand testing. It progressively increases till the end of the 72-hour constant rate testing. The sand content testing reaches a peak of approximately 7 ppm at the end of the 72-hour constant-rate testing.

4.6 WATER QUALITY TESTING RESULTS

During the last hour of the constant-rate test, Ranney hydrogeologist collected water samples that were submitted to Kuo Testing Laboratories (KTL), an Oregon State-certified laboratory Located in Pasco, Washington for laboratory analysis. The results of these analyses are included in Appendix C. The analyses conducted by KTL indicated iron was detected at a level of 0.07 milligram per liter (mg/l) which is significantly below the EPA drinking water standard, while manganese was undetected. The hardness was 110 mg/l and the total dissolved solids concentration was 153 mg/l. The pH of the discharge water sample was determined to be 8.0 S.U. and the total organic carbon level was 1.53 mg/l. The bacteria analysis indicated that the E-Coli and Fecal Coliform bacteria in the sample collected were undetected while Total Coliform is reported at a level of 6.3 MPN/100 ml.

4.7 POST-PERFORMANCE SAND CONTENT TESTING

After the performance testing, the sand testing results and the video from the AUS dive team during the multiple-rate testing were reviewed to access the cause of the elevated sand content. A decision to redevelop laterals 1 through 5 was reached. This additional redevelopment work was performed using the same methods described previously in this document. Following that additional redevelopment, post-performance sand content testing was conducted. This testing was completed between June 7th and June 8th, 2023 and was conducted at a pumping rate of 6490 gpm. Results from Table 4.7.0 shows that the observed sand content was below the specified requirements of 2 ppm after 22 hours of pumping. The re-tested sand concentrations were also below the sand concentrations from the performance test at equivalent times since the start of testing.

5 ESTIMATED YIELDS FOR THE COLLECTOR WELL

The yield capacity of a collector well can be separated into two components, the first component being the aquifer capacity and the second component being the mechanical capacity of the constructed well. The aquifer capacity is the quantity of water that the aquifer can sustainably deliver to the well. The aquifer capacity is dependent on the aquifer hydraulics including the hydraulic conductivity, saturated thickness, boundary conditions, and recharge conditions. The hydraulic conductivity of the aquifer is affected by changing temperatures, as the viscosity of water is inversely proportional to temperature. When the water is colder, the water is more viscous and the effective hydraulic conductivity of the aquifer is lower, resulting in lower well yields than when the water is warmer. Typically, the water levels in the alluvial aquifer are affected by the Columbia River, the saturated thickness of the aquifer varies with changes in the river level and can also vary with seasonal recharge changes and can also be affected by pumping from other wells.

The mechanical capacity of the well to extract the available water is dependent on the well's design and efficiency. The mechanical capacity of the well is the rate at which the well can be pumped without causing undue deleterious effects such as sand production and migration of fine materials to the screened zone or premature clogging of the well screen and aquifer materials adjacent to the well screen. Design factors that affect the mechanic capacity include the screen placement, screen length and diameter, and screen open area. The screen placement and static water levels in the aquifer control the available drawdown. The screen length, diameter, and open area control factors such as the velocity of the water approaching and entering the screen, and water velocity within the screen.

5.1 AQUIFER CAPACITY

Given that the results of the multiple-rate step test indicate that collector well is efficient in extracting water from the aquifer, the specific capacity of collector well can be used as an indication of the aquifer's ability to transmit water to the well. Using the performance testing data, it is possible to estimate the yield of CW3 under various conditions. To estimate CW3 yield, the following equation was utilized:

$$Q_2 = \frac{Q_1 \times m_2 \times s_2 \times v_1}{m_1 \times s_1 \times v_2}$$

Where:

Q = yield (gpm) of collector well under test (Q_1) and design (Q_2) conditions;
s = drawdown (ft) in collector well under test (s_1) and design (s_2) conditions;
m = aquifer thickness (ft) corrected for dewatering under test (m_1) and design (m_2) conditions; and
v = viscosity coefficient under test (v_1) and design (v_2) temperature conditions.

For Collector Well No. 3, the following values were utilized for the performance test yield determinations:

Yield Conditions	**72-hour Test**	
Top of Aquifer	268.0	Feet
Base of Aquifer	226.6	Feet
Static Groundwater Level		
Test Conditions	269.4	Feet
Summer Average	266.0	Feet
Winter Low	261.0	Feet
Test Pumping Rate	5945	GPM
Pumping Level		
Test Conditions (Projected 11.5 days)	238.9	Feet
Design Minimum Pumping Level	239.3	Feet
Water Temperature / Viscosity Coefficient		
Test Conditions	55° F / 1.08	
Summer Conditions	65° F / 0.93	
Winter Conditions	48° F / 1.20	

The yields were estimated for the conditions at the time of the performance testing and also for the assumed conditions with winter groundwater temperatures and low river levels and for summer groundwater temperatures and average river levels (Layne 1998 for static water levels). The calculated estimated yields are as follows:

Projected Estimated Yields for Collector Well 3

Test Conditions	5,945 gpm/8.6 MGD
Assumed Winter Low Conditions	3,950 gpm/5.7 MGD
Assumed Summer Average Conditions	6,940 gpm/10.0 MGD

The estimated yields for CW3 based on the performance testing results are depicted in Figure 5.1.1). The yields are 8.6 MGD (Test Conditions), 5.7 MGD (Winter Low Conditions), and 10.0 MGD (Summer Average Conditions).

The actual yields for CW3 will depend on how well the actual conditions match the assumed conditions and will vary with changes in factors such as the Columbia River levels, temperatures, and aquifer recharge conditions. The well yields can also be affected by changes in the distribution of riverbed sediments and the riverbed elevation based on the dam control over time. Reduction in the aquifer water levels due to pumping at the other nearby well sites would result in reduced capacity for the collector well. Another factor that could affect the yields over time is mineral and/or bacterial deposits form in the screen slot openings and in the pore spaces of the aquifer adjacent to the lateral well screens and if fine-grained aquifer materials migrate to the area around the well screens.

5.2 MECHANICAL WELL CAPACITY

Factors considered for establishing the mechanical capacity of a collector well include the entrance velocity for water moving through the well screen slots, the approach velocity of water moving through the aquifer adjacent to the laterals, and the in-line water velocity within the laterals.

The target specification for the average lateral screen entrance velocity is 1.0 foot per minute (ft/min). Given that CW3 has a total screen open area of 939 ft^2, at the pumping rate of 8.6 MGD, the average entrance velocity is calculated to be 0.85 ft/min, which is below the 1.0 ft/min threshold. The maximum pumping rate while remaining below this threshold is approximately 7,020 gpm.

The recommended limit for the velocity of the water in the aquifer as it approaches outside of the lateral screens is a function of the hydraulic conductivity of the aquifer. The recommended approach velocity limit is determined from the following equation (Williams, 1981):

$$v_a \le \frac{\sqrt{k}}{110}$$

Where:

v_a = the approach velocity in feet per minute (ft/min)
k = the aquifer hydraulic conductivity in gallons per day per square foot (gpd/ft^2)

Based on the information obtained during CW3 feasibility investigation and aquifer hydraulic conductivity value approximately of 320 feet/day (2,390 gpd/ft^2) was determined to be representative of the aquifer conditions in the vicinity of Site 2 location where Collector Well No. 3 is built (Layne, 1998). Using this hydraulic conductivity value and the expression above, the maximum of the average approach velocity should not exceed 0.44 ft/min, or 0.22 ft/min if a safety factor of two is applied.

The average approach velocity is determined by dividing the pumping rate by the circumferential area through which the flow occurs. The area is determined by the total length of the lateral well screen and the margin of the aquifer materials that have been affected by the development process where there is a potential for the transport of fines from the surrounding undeveloped aquifer materials. For 12-inch diameter screens, Ranney assumes a diameter of 1.33 feet for limit of the developed zone, which is the diameter of the temporary casing used to install the well screen. With 950 feet well screen, the average approach velocity at 6,000 (8.6 MGD) is equal to 0.21 ft/min, which is approximately equal to the approach velocity threshold if a safety factor is considered.

As a design criterion, Ranney uses an average maximum in-line velocity of the water in the laterals of 1.0 meter per second (m/sec) or 3.3 feet per second (ft/sec). The average in-line velocity is determined by dividing the flow rate by the total of the cross-sectional areas of the interiors of the laterals. With nine 12-inch diameter laterals, the proposed pumping rate of 6,000 gpm (8.6 MGD) results in an average in-line velocity of 1.89 ft/sec. At the design pumping rate of 6,000 gpm, the average in-line water velocity remains 1.89 ft/sec. This indicates there is little to no head loss due to the in-line velocity in the laterals at the design pumping rate.

Based on these results for CW3 as-built design, the limiting factor for the mechanical capacity is the approach velocity (if a safety factor of 2 is applied). Given the above considerations, it is recommended that the mechanical capacity of CW3 be considered as 7,020 gpm (10.1 MGD). Based on the performance test results, the Collector Well No. 3 was operated around the target yield of 6,000 gpm (8.6 MGD) during the performance testing, with significant available drawdown remaining. It is recommended that Collector Well No. 3 should not be pumped at a continuous rate exceeding the target yield of 6,000 gpm to minimize the potential for sand production, clogging of the well screens and aquifer materials adjacent to the screens by bacterial and or mineral deposits, and the migration of fines into the developed zone around the screens, and to maximize the time between any required redevelopment.

6 SUMMARY AND RECOMMENDATIONS

Ranney has completed the caisson, lateral installation, and performance testing of Collector Well No. 3 for the City of Boardman City, Oregon. The Collector Well No. 3 was designed to provide up to 8.6 MGD (6,000 gpm) under average river conditions. The source of this supply is groundwater derived from the sand and gravel deposits adjacent to the Columbia River.

The new collector well was constructed with a 16-foot ID caisson that is about 46.7 feet deep (from the top of the caisson to the top of the plug). The well is equipped with nine (9) stainless steel 12-inch ID wire-wrapped lateral screens. The centerline of the laterals in the caisson is at an elevation of 229.3 feet. The installed laterals have lengths that vary from 55 feet to 170 feet long, for a total linear length of 1,040 feet. The total screen open area in the Collector Well No. 3 is 939 feet^2. At the design pumping rate of 6,000 gpm, this would result in an average entrance velocity of 1.71 ft/min assuming 50% blockage of the screen slots.

Ranney conducted initial performance testing of the new collector well in May 2023. This testing was comprised of an 8-hour multiple-rate step test and a 72-hour constant-rate test. During the testing, water level data in the collector well and the adjacent observation well, pumping data, and other information were collected at pertinent intervals to evaluate the hydraulic character and productivity of the well.

The multiple-rate test was completed on May 19, 2023; during which the well was pumped at increasing rates of 1,962, 3,508, 4992, and 6,490 gpm, with each rate held for approximately two hours. Observed 2-hour drawdowns in the Collector Well No. 3 ranged from 3.27 feet at 1,962 gpm to 14.63 feet at the highest rate of 6,490 gpm. Analysis of the data collected shows the collector well to be highly efficient in delivering the available water.

The constant-rate test pumping was started on May 20th and continued until May 23rd, 2023, with recovery monitored until May 24th, 2023. During the test, the maximum drawdown in CW3 was about 22.04 feet at the pumping rate of 5,945 gpm, for a specific capacity of about 270 gpm/ft. The results of the testing of the new collector well are favorable, indicating that Collector Well No. 3 can yield 6,000 gpm (8.6 MGD). Excessive sand production during the test required additional development be performed on a number of the laterals. Following that additional redevelopment, an abbreviated test at 6,490 gpm indicated the sand production was well below the target threshold.

Ranney strongly recommends that CW3 should not exceed the target yield of 6,000 gpm in order to avoid reaching the 0.22 ft/min approach velocity threshold of the mechanical capacity if a safety factor of 2 is applied. Exceeding this pumping rate may lead to sand production, clogging of the well screens and aquifer materials adjacent to the screens by bacterial and or mineral deposits and/or the migration of fines into the developed zone around the screens. This may in turn require more frequent maintenance of the well and eventually diminish the efficiency and performance of the well.

It is also recommended that once CW3 is put into production, a well monitoring program should be initiated that includes the collection of such essential data as 1) Pumping Rates, 2) Pumping levels in CW3 and the adjacent observation well, 3) Static water levels in CW3 and any adjacent observation wells, 4) Water temperature of the pumped water and river, and 5) Columbia River. Initially, these data should be collected on at least a monthly basis. This program will provide a current and accurate determination of the operating trend of the Collector Well No. 3 enabling the tracking of the efficiency and yield potential of the well and impact upon surrounding wells under varying recharge conditions. This will allow future maintenance requirements to be easily assessed and scheduled at opportune times.

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