Location: Des Moines, Iowa

Operator: Des Moines Water Works

Permitting Agencies: Iowa Department of Natural Resources (IDNR); U.S. Environmental Protection Agency (USEPA); Federal Aviation Administration (FAA); Polk County Public Works Department; City of Des Moines, Iowa

Current MAR Status: In operation

Year Constructed: 2015–2018

Costs: $6.1M

Project Contact Information:

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Purpose of MAR:

- Water supply resilience

Source Water:

- Rivers/streams/lakes/reservoirs

Water Quality:

- Pretreatment required
- Post-treatment required

Recharge Technology(s):

- ASR well

Project Description

The Army Post Road ASR well facility is a joint project constructed by Des Moines Water Works (DMWW) under an agreement between DMWW, the City of West Des Moines, and the West Des Moines Water Works. The agreement follows the provisions of Chapter 28E of the Iowa Code and was executed in 2015.

The Chapter 28E Agreement states that the purpose for this project is to upgrade the capacity of the water supply infrastructure needed to support future development anticipated for West Des Moines. Included in the anticipated future development is a specific project for Microsoft Corporation, which requires a very high peak demand that could not be met without upgrading the capacity of the water supply system in the area. Construction of the Army Post Road ASR well facility is one of the upgrades needed to meet Microsoft Corporation's water needs. It also will benefit other future water users in this portion of the DMWW service area.

DMWW owns and operates similar ASR well facilities at the L. P. Moon ground storage facility in Dallas County and at the McMullen Water Treatment Plant in southwestern Polk County. As with the L. P. Moon and McMullen ASR well facilities, the Army Post Road ASR well facility injects finished/treated drinking water into a well completed in the Cambrian-Ordovician Aquifer. The drinking water injected into the wells during this "injection mode" is stored in the aquifer for later use during periods of high-water demand in the distribution system.

During high periods of demand, the injected drinking water is withdrawn from the aquifer and returned to the distribution system. This mode of operation is called the "recovery mode" and generally occurs during late spring and early summer. Recovery mode can also be used, however, during other periods that would benefit DMWW's operations. An example of such a period would be when the quality of DMWW's surface water sources is poor due to high nitrate concentrations.

Receiving Aquifer

The Jordan Aquifer is the receiving aquifer for the Army Post Road ASR well. What is locally called the "Jordan Aquifer" in the Des Moines area is actually a grouping of three formations: the Root Valley and Oneota Members of the Ordovician Prairie du Chien Formation and the Cambrian Jordan Sandstone (Young 1992; Young and Siegel 1992).

- The Root Valley Member is dolomitic, fine- to medium-grained sandstone with chert. It is 80–90 feet thick in this area.
- The Oneota Dolomite is a cherty, fine- to coarse-crystalline porous dolomite about 200 feet thick. The Oneota Dolomite is characterized regionally as fractured to highly fractured with some crevices producing most of the water in wells screened in the Jordan Aquifer (Horick, P. J. and Steinhilber 1978). Karst features such as fractures, vugs, and caverns form secondary porosity within the dolomite and are common in the Oneota Dolomite in Iowa.
- The Jordan Sandstone is a fine-grained sandstone with some medium- to coarse-grained sections. The sandstone mineralogy is quartz with potassium feldspar, and the sandstone is weakly cemented by dolomite, quartz, or feldspar (personal communication with Tom Miller, Iowa Department of Natural Resources Geological Service Bureau). The Jordan Sandstone is about 50 feet thick.

Regional transmissivity of the Jordan Aquifer ranges from 2,000 to more than 4,000 feet per day, with some of the higher values estimated in Polk County where the Army Post Road ASR well is located (CH2M Hill 1996).

Table 1 is a summary of the native Jordan Aquifer water quality. The native water exceeds primary drinking water Maximum Contaminant Levels (MCLs) for several regulated radionuclides (gross alpha, radium-226, and combined radium), as well as several Secondary Maximum Contaminant Levels (SMCL) (sulfates, TDS, fluoride) highlighted in bold in Table 1. The native water is highly mineralized, making it unpalatable as a source of drinking water for most customers. The environment is slightly reducing with measurable concentrations of dissolved iron that will precipitate when in contact with oxidants. Calcium concentrations are also elevated (220 mg/L as $CaCO_3$) but stable at native water pH (7.7).

Table 1—Native Jordan Aquifer water quality at Army Post Road ASR site

			Iowa Drinking Water Standards		Test Dates		
Analyte Group	Parameter	Units	MCLs	SMCLs	5/11/2017	5/12/2017	Average
On-site	pH	None		6.5 - 8.5	7.73	7.65	7.69
	Conductivity	uS/cm			1678	1681	1680
	Dissolved Oxygen	mg/l			NA	NA	NA
	Eh (ORP)	mV			NA	NA	NA
IOCs	**Sulfate**	mg/l		250	518	518	518
	Chloride	mg/l		250	75	77	76
	Fluoride	mg/l	4	2	2.79	2.8	2.8
	Nitrate	mg/l	10		ND	ND	ND
	Nitrite	mg/l			0.2	ND	ND
	Silica	mg/l			12	12	12
	Total Alkalinity	mg/l			272	268	270
	Total Hardness	mg/l			370	374	372
	Calcium Hardness	mg/l			219	221	220
	Magnesium Hardness	mg/l			151	152	152
	Non-carbonate Hardness	mg/l			98	106	102
	Total Dissolved Solids	mg/l		500	1230	1220	1225
	Chlorine	mg/l			ND	ND	ND
	Potassium	mg/l			18.0	18.0	18.0
	Sodium	mg/l			227	229	228
	Antimony	mg/l	0.006		ND	ND	ND
	Thallium	mg/l	0.002		ND	ND	ND
	Arsenic	mg/l	0.01		0.001	0.001	0.001
	Barium	mg/l	2		ND	ND	ND
	Cadmium	mg/l	0.005		ND	ND	ND
	Chromium	mg/l	0.1		ND	ND	ND
	Dissolved Iron	mg/l		0.3	0.223	0.218	0.221
	Manganese	mg/l		0.05	ND	ND	ND
	Selenium	mg/l	0.05		ND	ND	ND
	Mercury	mg/l	0.002		ND	ND	ND
	Zinc	mg/l		5	0.015	0.015	0.015
PHY	Total Suspended Solids	mgl			0.05	0.04	0.05
	Temperature Celsius	C			24.6	24.2	24.4
VOCs[1]		mg/l			ND	ND	ND
SOCs[1]		mg/l			ND	ND	ND
THMs[2]		mg/l	80		ND	ND	ND
HAAs[2]		mg/l	60		ND	ND	ND
RADS	**Gross Alpha**	pCi/L	15		17.5	22.9	20.2
	Radium-226	pCi/L	5		8	8.4	8.2
	Radium-228	pCi/L	5		2	2	2
	Combined Radiums	pCi/L	5		10	10.4	10.2
	Uranium	mg/l	0.03		ND	ND	ND
	Radon-222**	pCi/L	300		138	108	123
MICRO	Heterotrophic Plate Count	counts/ml				64	
	Total Coliforms	counts/ml			ND	ND	ND
	E. coli	counts/ml			ND	ND	ND
	Pseudomonas sp.	counts/ml			ND	ND	ND

[1] SDWA VOCs and SOCs

[2] DBPs MCL is based on total

** Proposed regulation

Water Quality

Water quality considerations at the Army Post Road ASR well include:

- Geochemical compatibility of source water and receiving aquifer water. Lime-softened finished water is considerably different from native Jordan Aquifer water. The source water is strongly oxidizing (400mV ORP) and has an elevated pH (9.5). Oxidation of ferrous iron and precipitation of calcium would therefore be expected at the recharge front. The extent to which these reactions occur with continued operation of the ASR well is monitored by DMWW because these reactions could impact aquifer integrity and water quality. Bacteria counts in the source water are very low due to disinfection. The source water can, however, support bacterial growth should the disinfectant be neutralized. Table 2 is a summary of source water quality during pilot testing.

Table 2—Source water quality at Army Post Road ASR site

			Standards		Shakedown			Cycle 1			Cycle 2			Cycle 3			Cycle 4		
Analyte Group	Parameter	Units	MCLs	SMCLs	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
On-site*	pH	None		6.5 - 8.5	9.50	9.77	9.66	9.51	9.77	9.69	9.51	9.77	9.59	9.30	9.40	9.34	8.93	9.36	9.16
	Conductivity	uS/cm			262	330	301	205	344	279	298	337	313	304	338	322.8	252	373	334
IOCs	Sulfate	mg/l		250	28.83	30.12	29.475	26.26	26.27	26.265	28.24	30.07	29.155	31.39	37.16	34.275	40.25	75.41	53.18333
	Chloride	mg/l		250	29.08	29.41	29.245	27.56	27.59	27.575	28.69	30.56	29.625	30.55	31.1	30.825	29.58	33.15	31.50667
	Fluoride	mg/l	4	2	0.7	0.8	0.75	0.74	0.74	0.74	0.31	0.56	0.435	0.73	0.78	0.755	0.74	0.79	0.773333
	Nitrate	mg/l	10		7.74	7.79	7.765	8.34	8.87	8.605	7.46	8.37	7.915	7.46	8.35	7.905	0.25	4.06	1.576667
	Nitrite	mg/l			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Silica	mg/l			6.7	6.7	6.7	11	11	11	6.7	8.4	7.55	6.9	8.4	7.65	7	7.7	7.35
	Total Alkalinity	mg/l			44	61	52.5	67	69	68	44	46	45	46	58	52	56	60	58
	Total Hardness	mg/l			114	134	124	143	145	144	123	127	125	128	129	128	92	122	114
	Calcium Hardness	mg/l			62	101	82	84	101	93	69	85	77	73	91	82	31	88	63
	Magnesium Hardness	mg/l			33	52	42	41	61	51	42	54	48	39	54	46	30	49	38
	Non-carbonate Hardness	mg/l			70	73	71	74	78	76	77	84	80	71	82	76	32	62	47
	Total Dissolved Solids	mg/l		500	176	209	192.5	209	211	210	176	186	181	197	209	203	203	278.5	240.75
	Free Chlorine	mg/l			1.09	1.14	1.108	0.93	1.28	1.024	0.99	1.09	1.056	1.12	1.42	1.312	0.95	1.46	1.145
	Sodium	mg/l			11.02	11.79	11.405	10	10.12	10.06	11.45	12.17	11.81	12.57	13.72	13.145	15.22	27.21	19.46
	Antimony	mg/l	0.006		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Thallium	mg/l	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Arsenic	mg/l	0.01		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Barium	mg/l	2		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Cadmium	mg/l	0.005		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Chromium	mg/l	0.1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Copper	mg/l	TT		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Lead	mg/l	TT		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Dissolved Iron	mg/l		0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Manganese	mg/l		0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Selenium	mg/l	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Mercury	mg/l	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Zinc	mg/l		5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PHY	TDS	mgl			176	209	192.5	209	211	210	176	186	181	197	209	203	203	278.5	240.75
	Total Suspended Solids	mgl																	
	Temperature Celsius	C			15.8	15.9	15.84	15.8	15.9	15.84	15.4	20.16	16.992	19.2	20.1	19.72	20.4	23.4	21.91667
VOCs[1]		mg/l			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SOCs[1]		mg/l			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
THMs[2]	Total Trihalomethanes	mg/l	0.08		0.019	0.0212	0.0201	0.0242	0.0242	0.0242	0.0234	0.0234	0.0234	0.028	0.0293	0.02865	0.0286	0.029	0.0288
HAAs[2]	Total Haloacetic Acids	mg/l	0.06		ND	0.007	0.0035	0.007	0.008	0.0075	ND	0.008	0.004	ND	ND	ND	ND	ND	ND
RADS[3]		pCi/L			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MICRO	Heterotrophic Plate Count	counts/ml			0	8	3	0	26	13	24	152	80	1	36	14	4	6	5
	Total Coliforms	counts/ml			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	E.coli	counts/ml			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Pseudomonas sp.	counts/ml			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

[1] SDWA VOCs and SOCs

[2] DBPs MCL is based on total

[3] RADS (Gross Alpha, Radium-226, Radium-228, Combined Radiums, Uranium, Radon)

** Proposed regulation

TT Treatment technology, action levels of 1.3 and 0.015 mg/l for Copper and lead respectively

- Quality of recovered water. Water quality deteriorates during recovery as native groundwater mixes with the injected water. During pilot testing of the Army Post Road ASR well, recovered water quality did not exceed MCLs for regulated substances until 100% recovery by volume during shakedown and cycle 1, where treated water contributed only 30% and 40% of the recovered water, respectively. The proportion of finished to recovered water increases with each successive injection cycle, so no primary drinking water standards will be exceeded when recovering injected water through 100% recovery by volume. However, the highly mineralized native groundwater caused exceedances of secondary drinking water standards for sulfate and TDS during pilot testing. In operation, DMWW monitors the TDS of the recovered water and halts recovery when the TDS approaches the secondary MCL of 500 mg/L.
- Disinfection. Approximately 680 feet of 30-inch diameter water main was installed from the ASR well house to the connection point to the water distribution system. A 30-inch diameter pipe was required to provide sufficient time for the water recovered from the ASR well to be in contact with the disinfectant and meet the required contact time value for 4-log inactivation of viruses by free chlorine before entering the distribution system. Carbon dioxide is added to the recovered water to adjust the pH downward to just below 9. This allows for a lower detention time and contact time value for the disinfection portion of the recovery process prior to the recovered water returning to the distribution system.
- Well clogging. It is possible that physical, mechanical, or biogeochemical processes will result in clogging of the ASR well such that reconditioning will eventually become necessary to maintain yield. DMWW continuously monitors the performance of its ASR wells and has not yet encountered any clogging issues after many years of operation.

Regulatory Considerations/Issues

Provisions of the underground injection control (UIC) permit issued by the USEPA include the following:

- Injection rate shall not exceed 2.5 million gallons per day (1,736 gallons per minute) nor shall the total storage volume during injection operations exceed 450 million gallons.
- Injection pressure, measured at the surface, shall not exceed 85 pounds per square inch gauge (psig).

- Monitoring provisions state that samples of the recovered water must be analyzed to determine whether any metals, such as arsenic, or radionuclides were mobilized by the injected water during storage in the aquifer. This requirement was based on the results of sampling and testing conducted during well development and pilot testing that showed concentrations of antimony and arsenic above their respective MCLs in the recovered water. There have been no detections of antimony or arsenic in testing of the recovered water conducted since the ASR system became operational.

Summary of permits required for the Army Post Road ASR well:

- Iowa Department of Natural Resources—Well Site Survey
- Iowa Department of Natural Resources—Limited Registration
- Iowa Department of Natural Resources—Construction Permit
- Iowa Department of Natural Resources—Water Use Permit
- Iowa Department of Natural Resources—General Permit No. 6 Well Discharge
- Iowa Department of Natural Resources—National Pollutant Discharge Elimination System (NPDES) General Permit No. 2
- City of Des Moines, Iowa Site Plan Approval

- USEPA Underground Injection Control Permit
- Federal Aviation Administration 7460-1 Permit