Metropolitan Water Reclamation District of Greater Chicago

MONITORING AND RESEARCH DEPARTMENT

REPORT NO. 17-30

TUNNEL AND RESERVOIR PLAN

MAINSTREAM TUNNEL SYSTEM

ANNUAL GROUNDWATER MONITORING REPORT

FOR 2016

August 2017

Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago
CECIL LUE-HING RESEARCH AND DEVELOPMENT COMPLEX
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July 26, 2017

Chief
Bureau of Water
Illinois Environmental Protection Agency
P. O. Box 19276
Springfield, IL 62794-9276

Dear Sir or Madam:

Subject: Tunnel and Reservoir Plan, Mainstream Tunnel System, Annual Groundwater Monitoring Report for 2016

Attached are three copies of the "Tunnel and Reservoir Plan, Mainstream Tunnel System, Annual Groundwater Monitoring Report for 2016."

Very truly yours,

Albert E. Cox
Environmental Monitoring and Research Manager
Monitoring and Research Department

AC:PL:cm
Attachment
cc w/att: Ms. Sally K. Swanson (USEPA Region 5 - WC15J) - (2)
Mr. Podczerwinski
Dr. Zhang
Dr. Cox
Dr. Tian
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TUNNEL AND RESERVOIR PLAN MAINSTREAM TUNNEL SYSTEM
ANNUAL GROUNDWATER MONITORING
REPORT FOR 2016

Monitoring and Research Department
Edward W. Podczerwinski, Acting Director

August 2017

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LIST OF ABBREVIATIONS

°C	degrees Celsius
CFU	colony forming units
Cl^-	chloride
EC	electrical conductivity
FC	fecal coliform
ft	feet
hr	hour
L	liter
m	meter
mg	milligram
mS	millisiemens
NH_3-N	ammonia nitrogen
SO_4^{2-}	sulfate
TDS	total dissolved solids
TOC	total organic carbon

ANNUAL DATA FOR MONITORING AND OBSERVATION WELLS

Introduction

The monitoring and observation wells are located along the length of the Mainstream Tunnel System between Morton Grove and Hodgkins, Illinois (Figures 1 and 2). The elevations for the observation wells are measured approximately 12 times per year, while the monitoring wells are sampled at various frequencies. Monitoring wells QM-53, -56, -58, -61, -66, -68 through -74, -76, -77, and -81 are all sampled three times per year (Illinois Environmental Protection Agency [IEPA] memoranda dated July 9, 2004, and February 23, 2006). Monitoring wells QM-62 through -65, -67, -75, -78 through -80, and -82 are all sampled six times per year (IEPA memorandum dated July 9, 2004). In 1994, the termination of monitoring for Wells QM-51, -52, -54, -55, -57, and -60 was approved by the IEPA (memorandum dated May 4, 1994). Monitoring well QM-65 could not be sampled throughout the year due to a faulty pump. Monitoring of observation well OM-17 was also discontinued with the approval of the IEPA (letter dated December 16, 2011). This well is scheduled for service later. Only two samples were retrieved from Well QM-66 in 2016. Monitoring well QM-59 has been dry since February 1995 and is no longer monitored.

Most monitoring wells in the Mainstream Tunnel System were sampled at the required frequencies. However, in a few instances, samples from specific wells could not be retrieved for various reasons. Throughout the year, monitoring samples were not collected from QM-56 due to a defective pump, and QM-58 was inaccessible due to closure of facilities in the vicinity of QM-58. In 2016, the required six samples were retrieved from Wells QM-62 and -82, unlike previous years. Both wells were considered intermittently dry in the past.

Summary of Data

Monitoring Wells. The analytical data for groundwater sampled during 2016 from monitoring wells QM-53 through QM-82 are presented in Table 1. Physical characteristics, such as elevation, groundwater temperature, and estimated time of recharge for each well between initial drawdown and sampling, are also included. Similar to year 2015, fecal coliform (FC) counts in Wells QM-61, -62, -63, -64, and -67 were much higher than expected at various times during the year. Three wells (QM-61, -64, and -68) were decontaminated earlier in the year, using the standard procedure, and significant reductions in FC counts were observed in Wells QM-64 and -68. Wells QM-61, -62, -63, -67, -68, -75, and -77 were all decontaminated on December 19, 2016.

Wells QM-62 and -63 were recently selected for special evaluation by U.S. Geological Survey personnel. Following this evaluation, both wells were serviced and decontaminated. The pumps in both wells and PVC pipe in QM-63 were replaced.

Table 2 lists the descriptive statistics for groundwater data of monitoring wells QM-53 through QM-82 for 2016.

FIGURE 1: MAP OF THE MONITORING WELLS IN THE MAINSTREAM TUNNEL SYSTEM

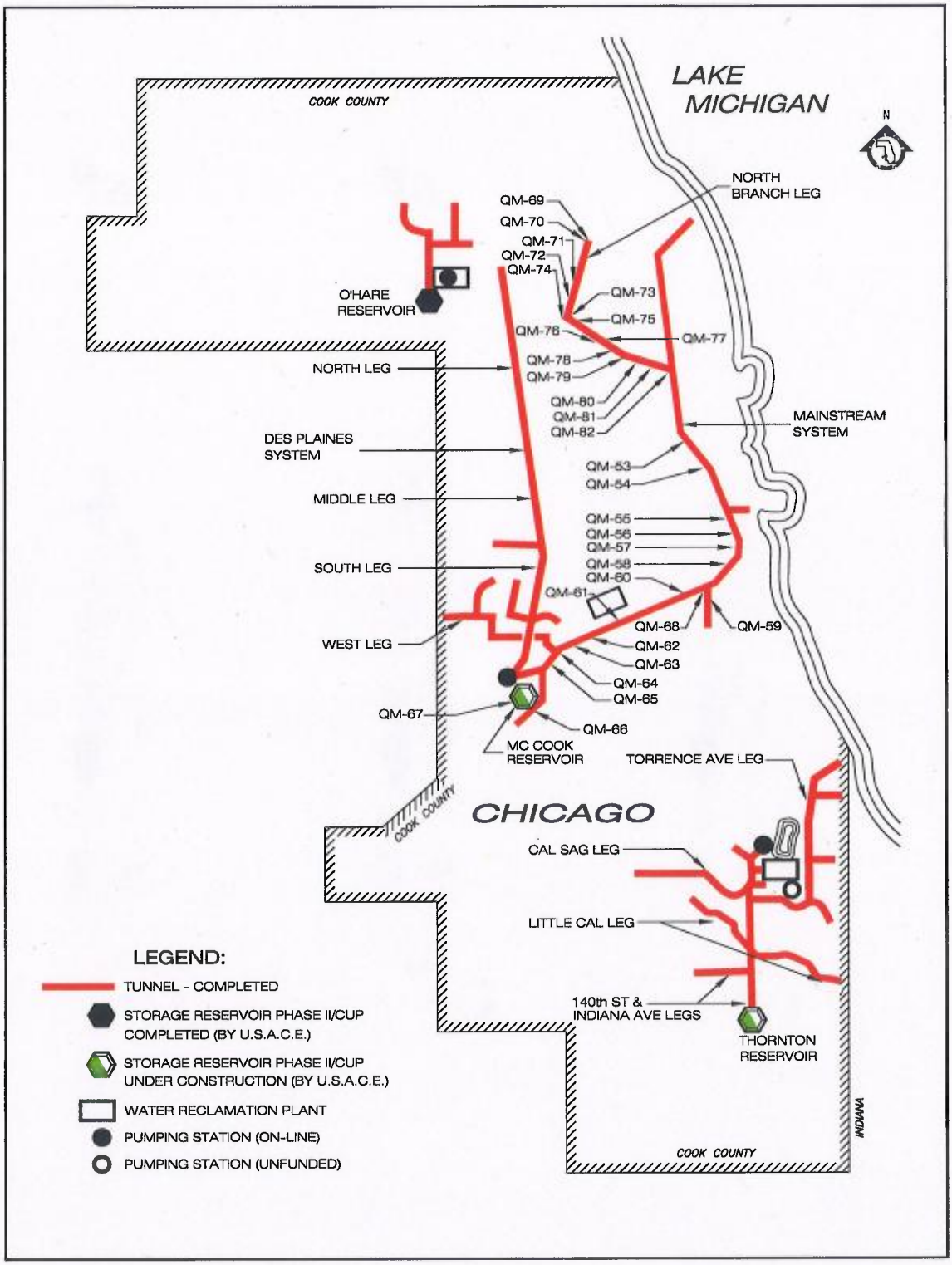

FIGURE 2: MAP OF THE OBSERVATION WELLS IN THE MAINSTREAM TUNNEL SYSTEM

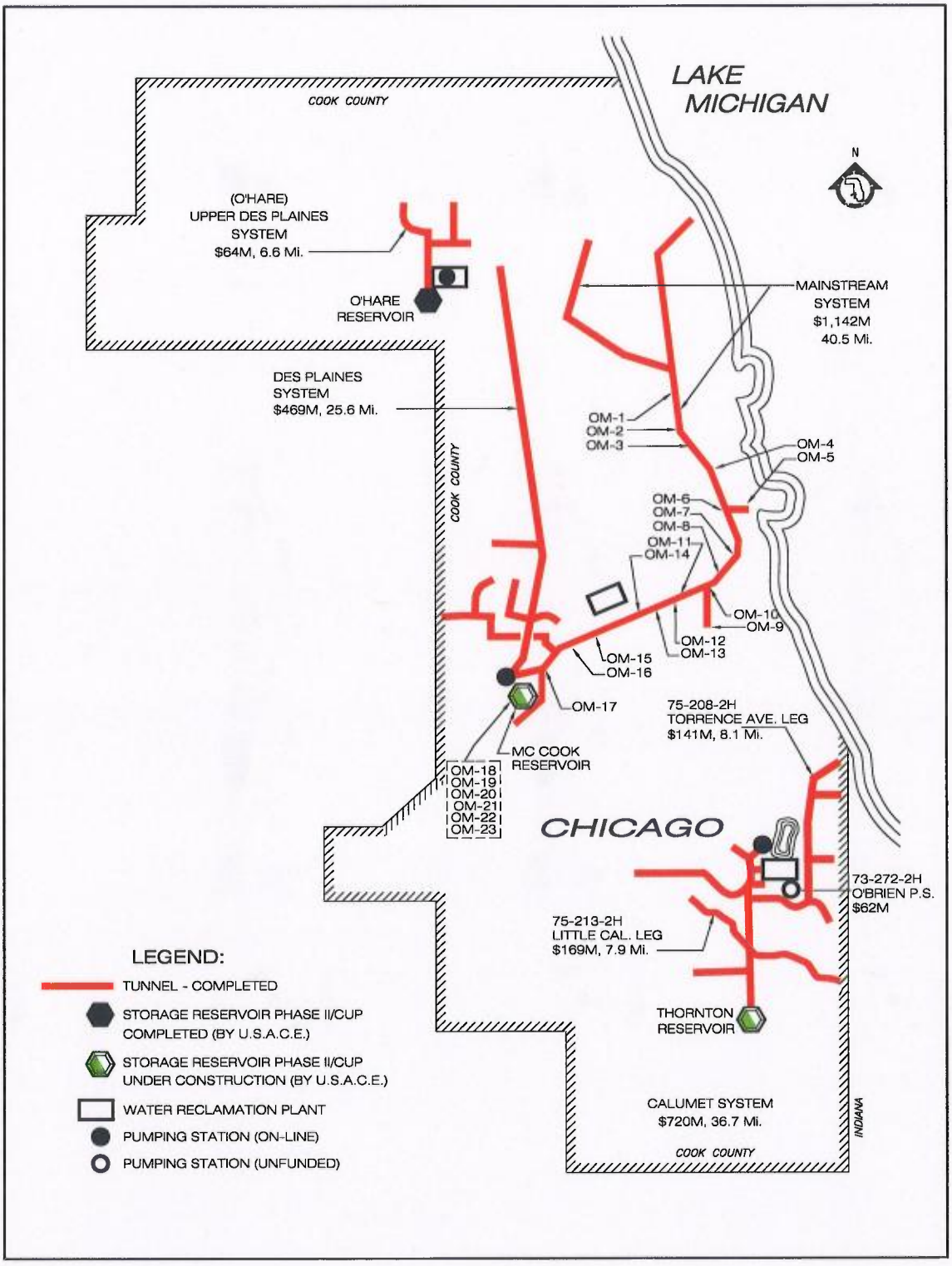

TABLE 1: ANALYSIS OF GROUNDWATER FROM WELLS QM-53 THROUGH QM-82 IN THE MAINSTREAM TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN SAMPLED DURING 2016

Well	Date Sampled	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform	Temp	Water Elevation[2]	Recharge Time
			mS/m	mg/L						CFU/100 mL	°C	ft	hr
QM-53	06/22/16	8.2	34	208	<1.0	16	37	0.11	152	<1	12.1	-36	<48
QM-53	09/08/16	8.3	35	220	<1.0	15	38	<0.10	149	<1	12.0	-34	<48
QM-53	12/07/16	8.2	35	128	<1.0	15	36	<0.10	152	<1	10.7	-35	<48
QM-61	02/03/16	7.6	56	270	<1.0	45	15	0.27	112	200	13.2	-142	<4
QM-61	06/27/16	7.3	75	388	<1.0	69	36	0.63	155	1,100	13.2	-147	<4
QM-61	09/08/16	7.4	68	382	1.2	66	29	0.65	162	2,900	15.1	-142	<4
QM-62	01/28/16	7.5	56	328	<1.0	54	30	0.16	151	140	13.0	-182	<48
QM-62	04/14/16	8.3	58	302	<1.0	47	27	0.43	152	160	14.4	-187	<48
QM-62	06/22/16	7.7	60	346	<1.0	52	19	0.60	155	1,400	14.2	-170	<48
QM-62	08/24/16	7.5	65	386	1.9	55	26	0.43	172	1,400	14.4	-164	<48
QM-62	10/05/16	7.3	56	342	1.5	72	18	0.54	175	14,200	14.9	-159	<48
QM-62	12/07/16	7.6	62	360	1.4	51	31	0.61	170	21	13.4	-177	<48
QM-63	01/28/16	7.3	184	1,688	2.3	49	994	2.2	927	4	13.1	-174	<48
QM-63	04/14/16	7.9	196	1,664	2.3	50	1,075	2.3	907	11	13.7	-178	<48
QM-63	06/22/16	7.5	150	1,710	1.6	51	950	2.0	829	7	13.8	-163	<48
QM-63	08/24/16	7.5	192	1,642	2.1	45	839	1.7	709	2,000	13.8	-160	<48
QM-63	10/05/16	7.4	152	1,532	2.6	48	971	2.1	849	3,300	14.2	-150	<48
QM-63	12/07/16	7.7	188	1,652	2.5	45	876	2.3	842	2	13.3	-166	<48
QM-64	02/03/16	7.5	69	402	<1.0	48	45	1.7	188	4	13.6	-148	<4
QM-64	03/24/16	8.0	76	408	1.1	47	40	1.5	183	<1	13.5	-169	<4
QM-64	06/27/16	7.5	70	420	<1.0	54	51	1.5	204	21	14.8	-156	<4

TABLE 1 (Continued): ANALYSIS OF GROUNDWATER FROM WELLS QM-53 THROUGH QM-82 IN THE MAINSTREAM TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN SAMPLED DURING 2016

Well	Date Sampled	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform	Temp	Water Elevation[2]	Recharge Time
			mS/m	mg/L						CFU/100 mL	°C	ft	hr
QM-64	07/25/16	7.2	75	372	1.2	43	54	1.6	203	9,000	15.9	-114	<4
QM-64	10/31/16	7.3	71	398	1.3	51	43	1.6	180	200	14.8	-165	<4
QM-64	12/14/16	7.2	75	390	1.3	49	39	2.0	201	14	13.2	-170	<4
QM-66	10/05/16	12.4	423	1,910	1.5	151	165	1.6	4	<1	14.5	-319	<48
QM-66	11/09/16	12.3	460	1,790	1.7	157	138	1.4	2	<1	14.0	-319	<48
QM-67	02/24/16	7.2	203	636	3.5	180	<5	12	237	32	13.7	-137	<48
QM-67	05/26/16	7.2	150	810	3.0	242	51	12	297	9	14.1	-158	<48
QM-67	06/22/16	7.5	148	820	2.7	218	73	12	318	510	14.2	-157	<48
QM-67	08/17/16	7.3	139	780	3.6	191	44	12	295	480	16.3	-157	<48
QM-67	10/05/16	7.4	135	706	4.2	161	25	12	289	980	15.0	-159	<48
QM-67	12/07/16	7.5	124	642	4.0	348	18	13	275	4,600	13.2	-157	<48
QM-68	05/26/16	7.4	105	1,242	1.6	138	37	0.74	396	<1	14.0	-106	<48
QM-68	08/17/16	7.5	104	630	1.4	140	40	0.75	389	<1	16.7	-107	<48
QM-68	10/26/16	7.0	111	662	2.0	138	41	0.85	414	<1	13.2	-112	<48
QM-69	05/26/16	8.1	49	286	1.1	39	37	0.83	152	<1	12.5	-26	<48
QM-69	08/17/16	7.7	50	288	1.8	35	37	0.86	146	<1	15.4	-30	<48
QM-69	11/09/16	8.0	50	302	1.1	35	37	0.90	146	<1	11.9	-30	<48
QM-70	02/10/16	8.0	52	338	<1.0	47	56	0.47	144	<1	11.0	-53	<48
QM-70	06/30/16	8.0	56	316	<1.0	48	57	0.42	153	<1	12.2	-51	<48
QM-70	09/15/16	8.1	57	342	<1.0	52	54	0.39	160	<1	12.8	-61	<48

TABLE 1 (Continued): ANALYSIS OF GROUNDWATER FROM WELLS QM-53 THROUGH QM-82 IN THE MAINSTREAM TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN SAMPLED DURING 2016

Well	Date Sampled	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform	Temp	Water Elevation[2]	Recharge Time
			mS/m	mg/L						CFU/100 mL	°C	ft	hr
QM-71	02/10/16	8.0	71	442	<1.0	120	67	0.49	180	<1	10.3	-63	<48
QM-71	06/30/16	8.1	74	502	<1.0	125	70	0.47	191	<1	12.2	-61	<48
QM-71	09/15/16	7.9	70	338	<1.0	126	68	0.48	195	<1	12.8	-53	<48
QM-72	05/26/16	7.9	67	472	1.0	131	<5	0.32	216	<1	12.2	-67	<48
QM-72	08/17/16	7.3	61	382	<1.0	127	<5	0.36	220	<1	12.8	-83	<48
QM-72	11/09/16	7.3	62	366	<1.0	123	<5	0.36	218	<1	12.9	-85	<48
QM-73	02/10/16	7.7	48	280	1.2	35	<5	0.26	143	<1	10.8	-161	<48
QM-73	06/30/16	7.9	52	310	<1.0	37	<5	0.27	154	<1	13.7	-161	<48
QM-73	09/15/16	7.9	51	296	1.0	35	<5	0.25	157	<1	14.5	-164	<48
QM-74	02/10/16	7.9	45	268	1.1	60	<5	0.24	99	<1	10.5	-12	<48
QM-74	06/30/16	7.9	49	282	<1.0	54	<5	0.20	107	<1	11.0	-11	<48
QM-74	09/15/16	7.9	48	264	1.4	58	<5	0.23	108	<1	15.6	-13	<48
QM-75	01/28/16	7.6	36	230	<1.0	13	110	0.22	65	<1	11.3	-77	<48
QM-75	04/14/16	8.1	40	218	<1.0	13	18	0.18	68	<1	13.2	-119	<48
QM-75	06/08/16	7.5	38	232	<1.0	14	10	0.25	62	1	12.9	-76	<48
QM-75	07/21/16	7.8	38	282	<1.0	13	11	0.26	63	1	12.3	-78	<48
QM-75	09/15/16	7.9	38	230	<1.0	12	11	0.25	64	<1	13.2	-82	<48
QM-75	12/22/16	7.5	37	218	<1.0	12	22	0.22	78	<1	11.6	-82	<48
QM-76	02/10/16	8.1	42	352	1.0	13	67	0.23	57	1	10.8	-186	<48
QM-76	07/21/16	8.0	56	376	<1.0	12	64	0.21	58	<1	12.8	-186	<48

TABLE 1 (Continued): ANALYSIS OF GROUNDWATER FROM WELLS QM-53 THROUGH QM-82 IN THE MAINSTREAM TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN SAMPLED DURING 2016

Well	Date Sampled	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform	Temp	Water Elevation[2]	Recharge Time
			mS/m	mg/L						CFU/100 mL	°C	ft	hr
QM-76	10/26/16	8.3	47	340	<1.0	11	64	0.21	59	<1	11.7	-186	<48
QM-77	02/10/16	8.2	24	196	<1.0	10	11	<0.10	45	27	12.5	-181	<48
QM-77	07/21/16	7.3	24	204	<1.0	10	<5	0.13	44	<1	14.3	-178	<48
QM-77	10/26/16	8.3	27	160	<1.0	11	<5	<0.10	43	12	12.0	-178	<48
QM-78	01/28/16	8.6	44	284	<1.0	10	46	<0.10	10	<1	11.1	-162	<48
QM-78	03/24/16	8.7	47	388	<1.0	13	44	<0.10	10	<1	11.1	-165	<48
QM-78	06/08/16	8.9	45	290	<1.0	11	42	<0.10	11	<1	12.1	-157	<48
QM-78	07/21/16	8.9	45	342	<1.0	11	42	<0.10	11	<1	12.1	-157	<48
QM-78	09/28/16	9.1	46	282	<1.0	11	41	<0.10	10	<1	11.8	-157	<48
QM-78	10/27/16	8.7	44	264	<1.0	10	40	<0.10	10	<1	11.6	-162	<48
QM-79	01/28/16	8.3	44	288	<1.0	15	27	<0.10	14	<1	10.8	-149	<48
QM-79	03/24/16	8.5	44	264	<1.0	14	20	<0.10	12	<1	10.9	-150	<48
QM-79	06/08/16	8.7	45	288	<1.0	15	19	<0.10	14	<1	12.0	-145	<48
QM-79	07/21/16	9.0	47	328	<1.0	15	21	<0.10	14	<1	11.9	-149	<48
QM-79	09/28/16	8.6	29	284	<1.0	14	21	<0.10	14	<1	11.6	-142	<48
QM-79	10/27/16	9.1	48	272	<1.0	14	19	<0.10	14	<1	11.4	-149	<48
QM-80	01/28/16	8.4	29	202	<1.0	12	<5	<0.10	21	<1	11.6	-138	<48
QM-80	03/24/16	8.5	30	254	<1.0	13	<5	<0.10	22	<1	11.9	-147	<48
QM-80	06/08/16	8.6	31	214	<1.0	13	10	<0.10	23	<1	12.5	-143	<48
QM-80	07/21/16	8.6	31	242	<1.0	13	8	<0.10	24	<1	12.7	-146	<48
QM-80	09/28/16	8.3	32	196	<1.0	12	<5	<0.10	23	<1	12.3	-123	<48

TABLE 1 (Continued): ANALYSIS OF GROUNDWATER FROM WELLS QM-53 THROUGH QM-82 IN THE MAINSTREAM TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN SAMPLED DURING 2016

Well	Date Sampled	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform	Temp	Water Elevation[2]	Recharge Time
			mS/m	mg/L						CFU/100 mL	°C	ft	hr
QM-80	10/27/16	8.5	31	184	<1.0	12	<5	<0.10	22	<1	12.1	-148	<48
QM-81	05/26/16	8.2	40	300	1.2	22	11	<0.10	31	<1	13.7	-121	<48
QM-81	08/17/16	8.1	39	240	<1.0	22	13	<0.10	37	<1	14.7	-123	<48
QM-81	11/09/16	8.0	40	224	<1.0	20	11	<0.10	31	<1	12.7	-124	<48
QM-82	01/28/16	8.3	43	288	1.1	29	9	<0.10	16	<1	12.0	-185	<48
QM-82	03/24/16	8.4	44	282	<1.0	29	9	<0.10	16	<1	12.1	-185	<48
QM-82	06/08/16	8.6	46	306	<1.0	29	12	<0.10	16	<1	12.9	-183	<48
QM-82	07/21/16	8.5	45	342	<1.0	30	14	<0.10	18	<1	14.1	-183	<48
QM-82	09/28/16	8.5	46	288	1.2	29	11	<0.10	18	<1	12.7	-170	<48
QM-82	10/27/16	8.5	45	280	1.1	30	13	<0.10	16	<1	12.6	-186	<48

[1]EC = electrical conductivity; TDS = total dissolved solids; TOC = total organic carbon.
[2]Relative to Chicago City Datum (579.5 ft above mean sea level) at intersection of Madison and State Streets.

TABLE 2: DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QM-53 THROUGH QM-82 IN THE MAINSTREAM TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m	mg/L						CFU/100 mL
QM-53	Minimum	8.2	34	128	<1.0	15	36	<0.10	149	<1
	Median	8.2	35	208	<1.0	15	37	<0.10	152	<1
	Mean	8.2	34	185	<1.0	15	37	0.10	151	<1
	Maximum	8.2	35	220	<1.0	16	38	0.11	152	<1
	Std. Dev	0.0	1	50	NA[3]	1	1	0.33	2	NA[3]
	Coeff. of Var. (%)	0.0	2	27	NA	4	3	321	1	NA
QM-61	Minimum	7.3	56	270	<1.0	45	15	0.27	112	20
	Median	7.4	68	382	0.0	66	29	0.63	155	110
	Mean	7.5	66	347	1.1	60	27	0.52	143	86
	Maximum	7.6	75	388	1.2	69	36	0.65	162	290
	Std. Dev	0.2	10	66	0.1	13	11	0.21	27	15
	Coeff. of Var. (%)	2.0	15	19	10.4	22	41	41.0	19	17
QM-62	Minimum	7.2	56	302	<1.0	47	18	0.16	151	2
	Median	7.6	59	344	1.2	53	26	0.48	162	78
	Mean	7.6	59	344	1.3	55	25	0.46	162	49
	Maximum	8.3	65	386	1.9	72	31	0.61	175	1,420
	Std. Dev	0.4	3	28	0.37	9	5	0.17	11	26
	Coeff. of Var. (%)	5.0	6	8	28.4	16	21	36.0	7	53

TABLE 2 (Continued): DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QM-53 THROUGH QM-82 IN THE MAINSTREAM TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m	mg/L						CFU/100 mL
QM-63	Minimum	7.3	150	1,532	1.6	45	839	1.7	709	<1
	Median	7.5	186	1,658	2.3	48	960	2.1	846	1
	Mean	7.5	177	1,648	2.2	48	951	2.0	844	4
	Maximum	7.9	196	1,710	2.6	51	1,075	2.2	927	330
	Std. Dev	0.2	20	62	0.4	3	85	0.2	77	29
	Coeff. of Var. (%)	3.0	12	4	16.0	5	9	10.0	9	735
QM-64	Minimum	7.2	69	372	<1.0	43	39	1.5	180	0
	Median	7.4	73	400	1.2	48	44	1.6	194	2
	Mean	7.4	73	398	1.2	49	45	1.6	193	5
	Maximum	8.0	76	420	1.3	54	54	2.0	204	900
	Std. Dev	0.3	3	16	1.1	4	6	0.19	11	17
	Coeff. of Var. (%)	4.0	4	4	99.0	8	13	12.0	6	326
QM-66	Minimum	12.3	423	1,790	1.5	151	138	1.3	2	<1
	Median	12.4	441	1,850	1.6	154	152	1.4	3	<1
	Mean	12.4	441	1,850	1.6	154	152	1.4	3	<1
	Maximum	12.4	460	1,910	1.7	157	165	1.5	4	<1
	Std. Dev	0.1	26	85	0.1	4	19	0.12	1	NA
	Coeff. of Var. (%)	1.0	6	5	9.0	3	13	8.0	47	NA

TABLE 2 (Continued): DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QM-53 THROUGH QM-82 IN THE MAINSTREAM TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m	mg/L						CFU/100 mL
QM-67	Minimum	7.2	124	636	2.7	161	5	12	237	1
	Median	7.4	144	743	3.6	204	35	12	292	50
	Mean	7.3	150	732	3.5	223	36	12	285	26
	Maximum	7.5	203	820	4.2	348	73	13	318	460
	Std. Dev	0.1	28	83	0.6	67	25	0.34	27	19
	Coeff. of Var. (%)	2.0	18	11	16.0	30	69	3.0	10	74
QM-68	Minimum	7.0	104	630	1.4	138	37	0.74	389	<1
	Median	7.4	105	662	1.6	138	40	0.75	396	<1
	Mean	7.3	107	845	1.7	139	39	0.78	400	<1
	Maximum	7.5	111	1,242	2.0	140	41	0.85	414	<1
	Std. Dev	0.2	3	344	0.3	1	2	0.06	13	NA
	Coeff. of Var. (%)	3.0	3	41	18.0	1	6	8.0	3	NA
QM-69	Minimum	7.6	49	286	1.1	35	37	0.83	146	<1
	Median	8.0	50	288	1.1	35	37	0.86	146	<1
	Mean	7.9	50	292	1.3	36	37	0.86	148	<1
	Maximum	8.1	50	302	1.8	39	37	0.9	152	<1
	Std. Dev	0.2	0.45	9	0.4	2	0	0.04	3	NA
	Coeff. of Var. (%)	3.0	1	3	30.0	6	0	4.0	2	NA

TABLE 2 (Continued): DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QM-53 THROUGH QM-82 IN THE MAINSTREAM TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m	mg/L						CFU/100 mL
QM-70	Minimum	8.0	52	316	<1.0	47	54	0.39	144	<1
	Median	8.0	56	338	<1.0	48	56	0.42	153	<1
	Mean	8.0	55	332	<1.0	49	55	0.43	152	<1
	Maximum	8.1	57	342	<1.0	52	57	0.47	160	<1
	Std. Dev	0.1	2	14	NA	3	1	0.04	8	NA
	Coeff. of Var. (%)	1.0	4	4	NA	5	3	9.0	5	NA
QM-71	Minimum	7.8	70	338	<1.0	120	67	0.47	180	<1
	Median	8.0	70	442	<1.0	125	68	0.48	191	<1
	Mean	8.0	72	427	<1.0	124	68	0.48	189	<1
	Maximum	8.1	74	502	<1.0	126	70	0.49	195	<1
	Std. Dev	0.1	2	83	NA	3	2	0.01	8	NA
	Coeff. of Var. (%)	1.0	3	19	NA	3	2	2.0	4	NA
QM-72	Minimum	7.3	61	366	<1.0	123	<5	0.32	216	<1
	Median	7.3	62	382	1.0	127	<5	0.36	218	<1
	Mean	7.5	63	407	<1.0	127	<5	0.35	218	<1
	Maximum	7.9	67	472	<1.0	131	<5	0.36	220	<1
	Std. Dev	0.4	3	57	NA	4	NA	0.02	2	NA
	Coeff. of Var. (%)	5.0	5	14	NA	3	NA	7.0	1	NA

TABLE 2 (Continued): DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QM-53 THROUGH QM-82 IN THE MAINSTREAM TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m	mg/L						CFU/100 mL
QM-73	Minimum	7.7	48	280	<1.0	35	<5	0.25	143	<1
	Median	7.9	51	296	<1.0	35	<5	0.26	154	<1
	Mean	7.8	50	295	1.1	36	<5	0.26	151	<1
	Maximum	7.9	52	310	1.2	37	<5	0.27	157	<1
	Std. Dev	0.1	2	15	0.12	1	NA	0.01	7	NA
	Coeff. of Var. (%)	1.0	4	5	11.0	3	NA	4.0	5	NA
QM-74	Minimum	7.8	45	264	<1.0	54	<5	0.20	99	<1
	Median	7.9	48	268	1.1	58	<5	0.23	107	<1
	Mean	7.9	47	271	1.2	57	<5	0.22	105	<1
	Maximum	7.9	49	282	1.4	60	<5	0.24	108	<1
	Std. Dev	0.04	2	9	0.15	3	NA	0.02	5	NA
	Coeff. of Var. (%)	0.5	4	3	12.0	5	NA	9.0	5	NA
QM-75	Minimum	7.5	36	218	<1.0	12	10	0.18	62	<1
	Median	7.7	38	230	<1.0	13	14	0.24	64	<1
	Mean	7.7	38	235	<1.0	13	30	0.23	67	<1
	Maximum	8.1	40	282	<1.0	14	110	0.26	78	<1
	Std. Dev	0.2	1	24	NA	1	39	0.03	6	NA
	Coeff. of Var. (%)	3.0	3	10	NA	6	130	13.0	9	NA

TABLE 2 (Continued): DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QM-53 THROUGH QM-82 IN THE MAINSTREAM TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m	mg/L						CFU/100 mL
QM-76	Minimum	8.0	42	340	<1.0	11	64	0.21	57	<1
	Median	8.1	47	352	<1.0	12	64	0.21	58	<1
	Mean	8.1	48	356	<1.0	12	65	0.22	58	<1
	Maximum	8.3	56	376	<1.0	13	67	0.23	59	<1
	Std. Dev	0.1	7	18	NA	1	2	0.01	1	NA
	Coeff. of Var.(%)	2.0	15	5	NA	8	2	5.0	2	NA
QM-77	Minimum	7.3	24	160	<1.0	10	<5	<0.10	43	<1
	Median	8.2	24	196	<1.0	10	5	<0.10	44	12
	Mean	7.9	25	187	<1.0	10	7	0.11	44	7
	Maximum	8.3	27	204	<1.0	11	11	0.13	45	27
	Std. Dev	0.6	1	23	NA	1	3.5	0.32	1	1
	Coeff. of Var.(%)	7.0	6	13	NA	6	50.0	287	2	19
QM-78	Minimum	8.6	44	264	<1.0	10	40	<0.10	10	<1
	Median	8.8	45	287	<1.0	11	42	<0.10	10	<1
	Mean	8.8	45	308	<1.0	11	42	<0.10	10	<1
	Maximum	9.0	47	388	<1.0	13	46	<0.10	11	<1
	Std. Dev	0.2	1	47	NA	1	2	NA	1	NA
	Coeff. of Var. (%)	2.0	3	15	NA	10	5	NA	5	NA

TABLE 2 (Continued): DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QM-53 THROUGH QM-82 IN THE MAINSTREAM TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m	mg/L						CFU/100 mL
QM-79	Minimum	8.3	29	264	<1.0	14	19	<0.10	12	<1
	Median	8.7	44	286	<1.0	14	20	<0.10	14	<1
	Mean	8.7	43	287	<1.0	14	21	<0.10	14	<1
	Maximum	9.1	48	328	<1.0	15	27	<0.10	14	<1
	Std. Dev	0.3	7	22	NA	1	3	NA	1	NA
	Coeff. of Var. (%)	3.0	16	8	NA	4	15	NA	6	NA
QM-80	Minimum	8.3	29	184	<1.0	12	<5	<0.10	21	<1
	Median	8.5	31	208	<1.0	12	<5	<0.10	22	<1
	Mean	8.5	31	215	<1.0	12	6	<0.10	22	<1
	Maximum	8.6	32	254	<1.0	13	10	<0.10	24	<1
	Std. Dev	0.1	1	27	NA	1	2.2	NA	1	NA
	Coeff. of Var. (%)	1.0	3	13	NA	4	36.0	NA	5	NA
QM-81	Minimum	8.0	39	224	<1.0	20	11	<0.10	31	<1
	Median	8.1	40	240	<1.0	22	11	<0.10	31	<1
	Mean	8.1	39	255	1.1	21	12	0.10	33	<1
	Maximum	8.2	40	300	1.2	22	13	<0.10	37	<1
	Std. Dev	0.1	0.58	40	1.1	1	1	0.32	3	NA
	Coeff. of Var. (%)	1.0	1	16	103	5	12	16	10	NA

TABLE 2 (Continued): DESCRIPTIVE STATISTICS FOR GROUNDWATER DATA OF MONITORING WELLS QM-53 THROUGH QM-82 IN THE MAINSTREAM TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN DURING 2016

Well	Statistic	pH	EC[1]	TDS[1]	TOC[1]	Cl^-	SO_4^{2-}	NH_3-N	Hardness	Fecal Coliform[2]
			mS/m	mg/L						CFU/100 mL
QM-82	Minimum	8.3	43	280	<1.0	29	9	<0.10	16	<1
	Median	8.5	45	288	1.0	29	12	<0.10	16	<1
	Mean	8.5	45	298	1.1	29	11	<0.10	17	<1
	Maximum	8.6	46	342	1.2	30	14	<0.10	18	<1
	Std. Dev	0.1	1	24	1.1	1	2	NA	1	NA
	Coeff. of Var. (%)	1.0	2	8	103	2	17	NA	6	NA

[1]EC = conductivity; TDS = total dissolved solids; TOC = total organic carbon.
[2]Geometric mean is evaluated since data are Log-Normally Distributed.
[3]Not applicable.

Observation Wells. Measurement of groundwater elevations for observation wells OM-1 through -23 was attempted at the required frequencies. Several measurements were not taken as planned due to a number of factors limiting access to these wells (Table 3, Footnote 3). Elevations were calculated relative to the Chicago City Datum (579.48 ft above mean sea level) at the intersection of Madison and State Streets (Table 3). The minimum, mean, and maximum values for each well were calculated and plotted to determine fluctuations in groundwater elevations during the year (Figure 3). Generally, these fluctuations appeared to be minimal throughout the year. However, Wells OM-12, -15, -16, -20, -21, and -23 appeared to experience significant fluctuations of 57, 41, 31, 59, 50, and 62 ft, respectively, which could indicate the possibility of exfiltration from the Mainstream tunnel during the year.

TABLE 3: GROUNDWATER ELEVATIONS FOR OBSERVATION WELLS OM-1 THROUGH OM-23 IN THE MAINSTREAM TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN MEASURED DURING 2016

	Observation Well No.										
Date[1]	OM-1	OM-2	OM-3	OM-4	OM-5	OM-6	OM-7	OM-8	OM-9	OM-10	OM-11
	Elevation (ft)[2]										
01/29/16	-47.8	-39.7	-43.7	-87.6	NA[3]	-40.4	-65.6	-52.2	-34.8	-29.0	-56.4
02/26/16	NA	-39.7	-43.7	-86.6	-68.5	-32.4	-64.6	-53.2	-34.8	-29.0	-55.4
03/31/16	-45.8	-38.7	-42.7	-87.6	-67.5	-37.4	-64.6	-51.2	-33.8	-28.0	-54.4
04/15/16	-45.8	-37.7	-42.7	-86.6	-66.5	-36.4	-64.6	-51.2	-33.8	-28.0	-54.4
05/13/16	NA	-34.7	-37.7	-74.6	-64.5	-33.4	-65.6	-50.2	-31.8	-24.0	-52.4
06/10/16	-45.8	-36.7	-40.7	-75.6	-66.5	-36.4	-64.6	-50.2	-32.8	-28.0	-54.4
07/08/16	-44.8	-39.7	-44.7	-84.6	-66.5	-38.4	-63.6	-49.2	-33.8	-27.0	-54.4
08/26/16	-45.8	-30.7	-42.7	-84.6	-66.5	-37.4	-63.6	-48.2	-37.8	-28.0	NA
09/30/16	-47.8	-39.7	-40.7	-82.6	-64.5	-38.4	-63.6	-51.2	-35.8	-26.0	-54.4
10/12/16	-45.8	-30.7	-39.7	-80.6	-63.5	-40.4	-61.6	-52.2	-35.8	-25.0	-53.4
11/10/16	NA	-39.7	NA	-85.6	-66.5	-39.4	-64.6	-52.2	-37.8	-28.0	-55.4
12/22/16	-45.8	-38.7	-37.7	-83.6	-64.5	-40.4	-63.6	-51.2	-37.8	-27.0	-53.4

TABLE 3(Continued) : GROUNDWATER ELEVATIONS FOR OBSERVATION WELLS OM-1 THROUGH OM-23 IN THE MAINSTREAM TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN MEASURED DURING 2016

Date[1]	Observation Well No.										
	OM-12	OM-13	OM-14	OM-15	OM-16	OM-18	OM-19	OM-20	OM-21	OM-22	OM-23
	Elevation (ft)[2]										
01/29/16	NA	NA	-67.8	-164	-94.7	-217	-79.5	-82.9	-80.9	-80.3	-225
02/26/16	-5.7	NA	-68.8	-163	-126	-230	-80.5	-83.9	-74.9	-77.3	-227
03/31/16	NA	NA	-70.8	-178	-124	-232	-79.5	-85.9	-73.9	-81.3	-229
04/15/16	NA	NA	-72.8	-180	-125	-230	-77.5	-82.9	-75.9	-83.3	-231
05/13/16	NA	NA	-75.8	-177	-124	-227	-77.5	-82.9	-72.9	-87.3	-229
06/10/16	NA	NA	NA	-139	-100	-227	-78.5	-75.9	-34.9	-73.3	-169
07/08/16	NA	NA	NA	-144	-112	-227	-80.5	-66.9	-64.9	-75.3	-183
08/26/16	NA	NA	NA	-146	-114	-227	-80.5	-54.9	-61.9	-75.3	-178
09/30/16	-62.7	NA	NA	-147	-112	-233	-80.5	-114	-84.9	-75.3	-219
10/12/16	NA	NA	-64.8	-154	-117	-225	-81.5	-91.9	-78.9	-72.3	-190
11/10/16	NA	NA	NA	-158	-120	-224	-80.5	-82.9	-80.9	-74.3	-217
12/22/16	NA	NA	NA	-158	-119	-221	-82.5	-75.9	-79.9	-76.3	-210

[1]Date measurements were taken.

[2]Relative to Chicago City Datum (579.48' above mean sea level) at intersection of State and Madison Streets.

[3]No reading. Well inaccessible due to closure of business, locked gates, snow accumulation, or heavy truck traffic; OM-13 broken.

FIGURE 2: MINIMUM, MEAN, AND MAXIMUM OF WATER ELEVATIONS FOR OBSERVATION WELLS OM-1 THROUGH OM-23 IN THE MAINSTREAM TUNNEL SYSTEM OF THE TUNNEL AND RESERVOIR PLAN MEASURED DURING 2016