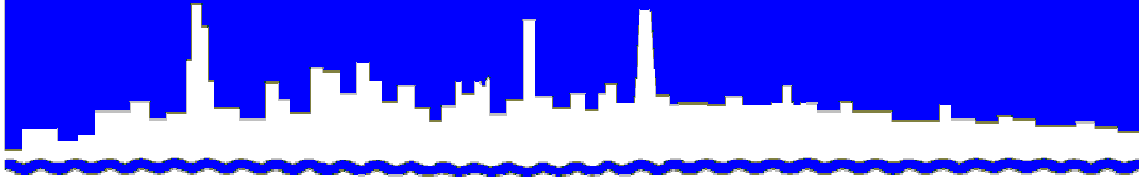


Protecting Our Water Environment



Metropolitan Water Reclamation District of Greater Chicago

***MONITORING AND RESEARCH
DEPARTMENT***

REPORT NO. 09-44

*EFFECTS OF POTENTIAL LEMONT WATER RECLAMATION PLANT
EXPANSION ON PHOSPHORUS LEVELS IN THE
CHICAGO SANITARY AND SHIP CANAL*

July 2009

Metropolitan Water Reclamation District of Greater Chicago

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**EFFECTS OF POTENTIAL LEMONT WATER RECLAMATION PLANT
EXPANSION ON PHOSPHORUS LEVELS IN THE
CHICAGO SANITARY AND SHIP CANAL**

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DISCLAIMER

Mention of proprietary equipment and chemicals in this report does not constitute endorsement by the Metropolitan Water Reclamation District of Greater Chicago.

SUMMARY AND CONCLUSIONS

The Lemont Water Reclamation Plant (WRP) is located in Lemont, Illinois, between the Chicago Sanitary and Ship Canal (CSSC) and the Illinois and Michigan Canal and serves a 20.6 square mile basin in Lemont Township.

As the population growth of the service area was expected to overtake the Lemont WRP's treatment capacity, the Metropolitan Water Reclamation District of Greater Chicago (District) began studying options to accommodate additional wastewater flow. Discussions with the Illinois Environmental Protection Agency (IEPA) revealed that new, more stringent treatment requirements on the allowable effluent limits would be imposed on the Lemont WRP should plant expansion take place. The Illinois interim effluent phosphorus (P) limit of 1 mg/L was among the new standards that would be applicable to the expanded plant (35 Ill Adm. Code 304).

Given the relatively low volume of effluent discharged into the CSSC from the Lemont WRP, it seemed unlikely that the plant would have any effect on P concentration in this already effluent-dominated waterway. To confirm this, the District performed monthly monitoring at two new locations directly upstream and downstream of the Lemont WRP to assess plant impacts on water quality in the CSSC between February 2006 and December 2008.

Thirteen water quality parameters were measured, including total phosphorus (TP) and chlorophyll *a*. There was no significant difference between TP or chlorophyll *a* concentrations at the two stations. Mean TP upstream of the Lemont WRP was 0.91 mg/L, while the downstream concentration was 0.90 mg/L. Mean chlorophyll *a* was 5 µg/L upstream and 5 µg/L downstream of the Lemont WRP.

There was no statistical difference between TP load upstream and downstream of the Lemont WRP in the CSSC during the project period. Likewise, the projected TP load downstream following an expansion at Lemont WRP would not be significantly different than upstream.

INTRODUCTION

The District owns and operates the Lemont WRP, located in Lemont, Illinois, between the CSSC and the Illinois and Michigan Canal. It serves a 20.6 square mile basin in Lemont Township which is located in the southwest extreme of Cook County.

The original plant, completed in November 1961, consisted of a pump station, grit chamber, two Imhoff tanks, trickling filter, and final settling tank. In June 1972, a new plant was completed, having been constructed on the foundations of the old one. The plant was upgraded and expanded in 1995 and is rated at 2.3 million gallons per day (MGD) design average flow (DAF), and 4.0 MGD design maximum flow (DMF). The present plant consists of grit and screen chambers, a pump station, three primary settling tanks, three aeration tanks, four final settling tanks, an effluent polishing tank, and a solids concentration tank. Concentrated solids are trucked to the Stickney WRP.

During 2005, the District explored planning and design options for Lemont WRP expansion or some acceptable alternative, as the population growth of the service area was expected to overtake the Lemont WRP's treatment capacity. Discussions with the Illinois Environmental Protection Agency (IEPA) revealed that new, more stringent treatment requirements on the allowable effluent limits would be imposed on the Lemont WRP should the expansion take place. The Illinois interim effluent phosphorus (P) limit of 1 mg/L was among the new standards that would be applicable to the expanded plant (35 Ill Adm. Code 304). Given the relatively low volume of effluent discharged into the CSSC from the Lemont WRP, it seemed unlikely that the plant would have any effect on P concentration in this already effluent-dominated waterway. Between February 2006 and December 2008, the District performed monthly monitoring at two new locations directly upstream and downstream of the Lemont WRP to assess plant impacts on water quality in the CSSC. This report will outline and discuss the results of these water quality monitoring efforts.

Characterization of the Receiving Waterway

The Lemont WRP discharges to the CSSC at River Mile (RM) 300.6, 10.5 miles upstream of the confluence of the CSSC with the Des Plaines River and 9.4 miles upstream of the Lockport Powerhouse and Lock (LP&L), which artificially controls water discharges and levels in conformance with federal regulations. The Stickney Water Reclamation Plant has the capacity to treat 1.2 billion gallons of wastewater each day and discharges into the CSSC approximately 16 miles upstream of the Lemont WRP. The CSSC is a 31.1-mile long man-made channel constructed during the period 1892-1907 with varying cross sections. Its alignment is straight throughout its length, except for four bends, near Harlem Avenue, LaGrange and Romeoville Roads, and in Lockport. Upstream of the LP&L, the channel depth varies from 20-27 feet. In the 2.4 mile reach immediately upstream of the LP&L, the width varies from 160-300 feet. The east bank of this reach is a vertical concrete wall, and the west bank varies from vertical dock wall to a steep rockfill embankment. The 14.6 miles upstream of this reach have vertical concrete or rock walls with 160 feet width.

Given the physical characteristics of this man-made waterway, there is very little habitat available for aquatic life. The CSSC cannot sustain a balanced and diverse warm-water fish and macroinvertebrate community. The fish community is comprised of tolerant species, including carp, gizzard shad, golden shiner, bluntnose minnow, and green sunfish.

The CSSC is currently designated as a Secondary Contact and Indigenous Aquatic Life Water as prescribed by the Illinois Pollution Control Board (IPCB) Regulations, Section 303.441, and must meet the water quality standards of Subpart D, Part 302. There currently are no water quality standards for P.

MATERIALS AND METHODS

Water Samples

Water grab samples were taken in a rinsed bucket from a boat in the center of the waterway. Samples were poured off into appropriate containers and kept in a dark, ice-packed cooler immediately after collection until delivery to the Analytical Laboratory Division login area. Water quality constituents measured, as well as analytical methods utilized, are listed in [Table 1](#). While several water quality constituents were measured, the focus of this study was TP concentrations upstream and downstream of the Lemont WRP.

Sampling Stations and Frequency

Stream water sampling occurred once per month on the 3rd Monday of each month between February 2006 and December 2008. The upstream location was at RM 302.6, which is two miles upstream of the Lemont WRP. The downstream station was located about 0.7 mile downstream of the outfall at RM 299.9.

Statistical Analysis

Statistical analyses were performed to determine whether there was a significant difference between the TP load upstream and downstream of the Lemont WRP under current conditions and with the projected loading estimate given the plant expansion. The correlation between upstream and downstream TP loads and upstream and projected downstream TP loads was greater than 0.99, indicating that a regression analysis (RA) would be more appropriate than a standard analysis of variance (ANOVA). Utilizing RA, each TP load upstream of the plant was compared for equality to each TP load downstream of the plant. The RA included testing the hypothesis that the slope of the regression was equal to one ($\beta = 1$).

TABLE 1: LEMONT EXPANSION PROJECT WATER QUALITY CONSTITUENTS
MEASURED AND ANALYTICAL METHODS

Water Quality Constituent	Analytical Method	Method Reference
Water Temperature	Electrode ^a	SM 2550 B
pH	Electrode ^a	SM 4500-H B
Turbidity	Nephelometric	SM 2130 B
Dissolved Oxygen	Iodometric	SM 4500-O C
Total Phosphorus	Colorimetric	EPA 365.4
Chlorophyll <i>a</i>	Spectrophotometric	SM 10200-H
Ammonia-Nitrogen	Colorimetric	EPA 350.1
Nitrate-Nitrogen	Colorimetric	EPA 353.2
Nitrite-Nitrogen	Colorimetric	EPA 353.2
Total Kjeldahl Nitrogen	Colorimetric	EPA 351.2
Total Suspended Solids	Gravimetric	SM 2540 D
Volatile Suspended Solids	Gravimetric	SM 2540 E
Fecal Coliform	Membrane	SM 9222 D

^aField measurement taken during water sampling events.

RESULTS AND DISCUSSION

Tables 2 and 3 present water chemistry results upstream of the Lemont WRP at RM 302.6 and downstream at RM 299.9, respectively. There was no significant difference between TP or chlorophyll *a* (a surrogate estimate of algal biomass) concentrations at the two stations. Mean TP upstream was 0.91 mg/L, while the downstream concentration was 0.90 mg/L. Mean chlorophyll *a* was 5 µg/L both upstream and downstream of the Lemont WRP.

Estimated Proposed Pollutant Load Increase from Lemont Water Reclamation Plant Expansion

The proposed plant expansion would ultimately have resulted in a DAF of 4.2 MGD and a DMF of 8.5 MGD (increased from current DAF and DMF of 2.3 and 4.0 MGD). The average flow of the CSSC at Romeoville, 4.3 miles downstream of the Lemont WRP is approximately 3,346 cubic feet per second, based on the United States Geological Survey gage. The percentage of current DAF and DMF from the Lemont WRP represent 0.11% and 0.19% of the flow in the CSSC, respectively. The estimated increased DAF and DMF would have increased the percentage of flow from Lemont WRP to 0.19% and 0.39%, respectively.

Table 4 displays the estimated TP load upstream and downstream of the Lemont WRP on 2006-2008 sampling dates, as well as the projected downstream TP load considering proposed plant expansion. These load values were calculated by multiplying the TP concentration by the flow volume in the waterway. They are estimates based on the grab sample concentration of TP and the daily average flow in the CSSC. Very high load values, such as the values estimated for August 20, 2007, are due to extremely high flow in the CSSC that day. However, our purpose is to compare the loadings using a consistent estimation method. The projected TP load was calculated assuming that the concentration of TP remained constant and the flow from the plant increased. This is a conservative estimate considering that the non-point sources of TP will not be affected by the plant expansion.

RA confirmed that for both conditions, comparing current upstream with downstream TP load and comparing current upstream with projected downstream load, the slope of each line is one, with a p-value less than 0.05. Therefore, there is no statistical difference between the upstream and downstream TP load, either under current conditions or with the projected load given a plant expansion. Given the relatively small TP loading from the Lemont WRP to the CSSC and the low effluent volume discharging from the Lemont WRP, the Lemont expansion would not have resulted in a significant downstream increase in TP or adverse environmental impact on the CSSC.

After studying various options, the District plans to decommission the Lemont WRP and replace it with a pump station and reservoir which will serve to divert wastewater flow to the Stickney WRP for treatment.

TABLE 2: WATER CHEMISTRY UPSTREAM OF THE LEMONT WATER RECLAMATION PLANT AT RIVER MILE 302.6 DURING 2006-2008

Date	Water Temp (°C)	pH (units)	Turbidity (NTU)	DO	TP	Chl-a (µg/L)	TKN	NH3-N	NO3-N	NO2-N	TN	TSS	VSS	Fecal Coliform (cfu/100 mL)
02/21/06	ND	ND	5	7.6	0.91	4	2.05	0.26	5.93	0.09	8.07	<10	<10	170
03/20/06	14.3	7.2	16	7.7	1.05	4	1.97	0.52	7.51	0.16	9.64	19	<10	200
04/17/06	13.0	6.0	20	5.8	1.30	7	1.86	0.47	6.12	0.15	8.12	19	<10	4,900
05/15/06	14.9	7.2	7	4.0	0.71	2	1.86	0.54	5.68	0.23	7.77	<10	<10	2,600
06/19/06	23.9	7.3	5	4.4	0.92	9	1.94	1.02	5.64	0.35	7.93	<10	<10	400
07/17/06	28.0	7.3	13	4.8	0.77	5	1.31	0.43	3.51	0.13	4.94	17	17	350
08/21/06	28.7	7.5	9	4.8	0.70	3	0.83	0.28	4.40	0.10	5.33	<10	<10	2,100
09/18/06	ND	ND	14	4.0	0.52	2	1.11	0.33	3.70	0.06	4.87	<10	<10	1,700
10/16/06	13.6	7.4	7	6.3	0.68	4	1.26	0.35	7.88	0.08	9.22	<10	<10	2,100
11/20/06	8.9	7.4	11	8.0	0.95	1	1.32	0.28	6.29	0.15	7.76	14	<10	940
12/18/06	11.5	7.1	8	6.4	0.41	2	1.33	0.41	4.60	0.51	6.44	34	26	220
01/16/07	8.5	7.4	8	7.5	0.68	2	1.26	0.33	5.68	0.24	7.18	16	<10	1,000
02/20/07	9.8	6.9	6	8.0	0.62	2	2.48	0.75	8.50	0.20	11.18	<10	<10	20
03/19/07	8.3	7.3	6	7.4	0.68	4	2.46	1.49	6.24	0.23	8.93	22	<10	420
04/16/07	15.5	7.3	9	7.2	0.50	5	1.42	0.48	3.77	0.09	5.29	32	<10	2,900
05/21/07	21.3	7.3	8	3.5	0.61	11	2.20	1.03	4.08	0.27	6.55	11	<10	200
06/18/07	28.7	7.5	9	5.8	1.01	18	1.42	0.29	4.60	0.14	6.16	19	<10	200
07/16/07	26.0	7.2	11	4.7	0.92	16	2.09	0.53	4.30	0.20	6.59	15	<10	380
08/20/07	24.0	7.5	51	4.0	0.93	5	1.59	0.39	3.17	0.09	4.85	58	13	120,000
09/17/07	21.0	7.5	10	5.7	0.65	4	1.00	0.29	3.84	0.06	4.90	13	<10	430
10/15/07	20.4	7.2	10	5.8	1.97	2	1.34	0.27	7.94	0.10	9.37	<10	<10	970
11/19/07	12.5	7.4	6	5.7	1.81	2	1.58	0.22	8.82	0.13	10.52	28	22	1,300
01/22/08	4.4	7.4	8	7.8	1.20	2	1.16	0.28	7.28	0.36	8.79	<10	<10	860
02/19/08	8.5	8.4	30	9.0	0.43	2	1.60	0.66	3.54	0.09	5.23	34	<10	22,000
03/17/08	11.3	7.3	6	7.0	1.18	4	1.46	0.58	9.27	0.11	10.84	<10	<10	140
04/21/08	23.0	7.3	6	5.6	0.79	6	1.98	1.13	5.34	0.23	7.55	10	<10	200
05/19/08	19.7	7.6	7	5.7	0.75	8	1.39	0.39	5.66	0.11	7.16	<10	<10	90

TABLE 2 (Continued): WATER CHEMISTRY UPSTREAM OF THE LEMONT WATER RECLAMATION PLANT AT RIVER MILE 302.6 DURING 2006-2008

Date	Water Temp (°C)	pH (units)	Turbidity (NTU)	DO	TP	Chl-a (µg/L)	TKN	NH3-N	NO3-N	NO2-N	TN	TSS	VSS	Fecal Coliform (cfu/100 mL)
06/16/08	23.6	7.1	8	5.6	0.75	15	1.38	0.51	5.47	0.22	7.07	13	<10	380
07/21/08	24.8	7.4	15	6.3	1.12	14	1.44	0.40	4.13	0.13	5.71	23	<10	4,000
08/18/08	26.4	7.1	6	5.8	1.71	11	1.09	0.38	5.76	0.10	6.95	<10	<10	580
09/15/08	20.2	7.4	35	6.6	0.30	2	1.13	0.30	0.07	0.06	1.26	52	11	59,000
10/20/08	17.9	8.7	8	5.5	1.31	2	1.38	0.45	6.68	0.17	8.23	12	<10	460
11/17/08	13.2	7.3	7	5.6	1.48	1	1.89	0.56	9.62	0.21	11.72	10	<10	1,000
12/15/08	6.9	7.5	15	7.4	0.56	3	1.38	0.41	4.62	0.29	6.29	27	10	950
Minimum	4.4	6.0	5	3.5	0.30	1	0.83	0.22	0.07	0.06	1.26	<10	<10	20
Maximum	28.7	8.7	51	9.0	1.97	18	2.48	1.49	9.62	0.51	11.72	58	26	120,000
Mean	17.3	7.4	12	6.1	0.91	5	1.56	0.50	5.58	0.17	7.31	18	11	838

ND= NO DATA

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TABLE 3: WATER CHEMISTRY DOWNSTREAM OF THE LEMONT WATER RECLAMATION PLANT AT RIVER MILE 299.9 DURING 2006-2008

Date	Water Temp (°C)	pH (units)	Turbidity (NTU)	DO	TP	Chl-a (µg/L)	TKN	NH3-N	NO3-N	NO2-N	TN	TSS	VSS	Fecal Coliform (cfu/100 mL)
02/21/06	ND	ND	8	5.3	1.10	5	2.24	0.28	6.66	0.11	9.00	<10	<10	470
03/20/06	13.7	7.0	15	8.1	0.87	4	1.65	0.46	7.00	0.14	8.79	12	<10	160
04/17/06	13.0	6.0	20	6.3	1.15	7	1.93	0.44	6.41	0.16	8.50	34	18	2,500
05/15/06	15.5	7.2	5	4.6	0.92	3	1.52	0.42	5.58	0.18	7.27	16	<10	1,400
06/19/06	22.7	7.2	7	4.5	0.82	14	2.22	1.09	5.27	0.37	7.85	<10	<10	340
07/17/06	27.8	7.3	8	5.4	0.63	8	1.30	0.40	3.75	0.13	5.18	11	11	350
08/21/06	26.7	7.4	17	5.4	0.81	2	1.16	0.31	4.09	0.10	5.34	20	10	1,400
09/18/06	ND	ND	16	4.9	0.65	1	1.12	0.35	4.09	0.06	5.28	25	<10	3,000
10/16/06	13.0	7.5	7	6.2	0.55	3	1.25	0.30	6.11	0.07	7.43	<10	<10	790
11/20/06	12.4	7.5	8	6.7	1.00	1	1.26	0.29	7.06	0.20	8.52	11	<10	1,300
12/18/06	11.6	7.1	13	5.9	0.47	2	1.39	0.47	4.42	0.49	6.30	13	10	190
01/16/07	9.3	7.3	11	8.1	0.75	5	1.04	0.16	6.26	0.11	7.40	15	<10	1,000
02/20/07	8.0	7.0	6	6.6	0.97	3	1.74	0.72	6.95	0.15	8.84	15	12	50
03/19/07	8.3	7.3	8	7.5	0.74	4	1.75	0.80	5.82	0.17	7.73	<10	<10	260
04/16/07	15.3	7.5	6	6.6	0.53	5	1.44	0.51	3.78	0.10	5.32	26	<10	1,600
05/21/07	19.9	7.2	5	2.9	0.59	9	2.21	1.05	4.27	0.29	6.77	<10	<10	140
06/18/07	26.6	7.5	11	5.3	1.08	18	1.45	0.36	4.40	0.20	6.05	12	<10	210
07/16/07	25.9	7.3	10	5.2	0.94	13	1.56	0.51	5.08	0.19	6.83	28	<10	440
08/20/07	24.1	7.5	72	4.3	0.98	5	1.34	0.31	3.03	0.08	4.45	119	22	67,000
09/17/07	21.4	7.6	13	4.8	0.62	3	1.03	0.34	3.69	0.08	4.80	17	<10	350
10/15/07	20.5	7.3	10	5.5	1.76	2	1.25	0.22	7.32	0.10	8.67	<10	<10	600
11/19/07	12.2	7.4	4	5.8	1.64	2	1.45	0.22	8.53	0.12	10.10	15	<10	1,500
01/22/08	11.0	7.0	7	7.4	1.14	2	1.27	0.40	7.46	0.46	9.19	<10	<10	360
02/19/08	6.6	8.4	51	8.0	0.53	3	1.90	0.74	3.22	0.10	5.23	50	<10	22,000
03/17/08	9.6	7.2	5	7.1	1.18	4	1.43	0.64	8.95	0.12	10.50	<10	<10	470
04/21/08	21.6	7.6	8	6.7	0.72	7	1.46	0.73	5.98	0.18	7.61	12	<10	90
05/19/08	19.8	7.6	8	5.8	0.70	5	1.40	0.38	5.68	0.11	7.19	<10	<10	130

TABLE 3 (Continued): WATER CHEMISTRY DOWNSTREAM OF THE LEMONT WATER RECLAMATION PLANT
AT RIVER MILE 299.9 DURING 2006-2008

Date	Water Temp (°C)	pH (units)	Turbidity (NTU)	DO	TP	Chl-a (µg/L)	TKN	NH3-N	NO3-N	NO2-N	TN	TSS	VSS	Fecal Coliform (cfu/100 mL)
06/16/08	25.6	7.3	8	5.2	0.71	14	1.25	0.41	5.77	0.16	7.17	15	<10	400
07/21/08	25.2	7.4	14	4.8	1.04	14	1.32	0.38	3.99	0.13	5.44	20	<10	3,800
08/18/08	26.3	7.3	10	6.6	1.28	9	0.94	0.27	4.55	0.09	5.58	<10	<10	340
09/15/08	24.0	7.2	36	6.1	0.27	3	1.13	0.27	0.07	0.05	1.25	56	11	33,000
10/20/08	18.4	7.7	7	6.3	1.31	2	1.12	0.26	6.83	0.09	8.04	<10	<10	260
11/17/08	12.5	7.5	10	6.0	1.44	4	1.24	0.23	9.22	0.12	10.59	13	<10	350
12/15/08	6.8	7.8	14	9.0	0.57	3	1.66	0.69	4.31	0.38	6.35	22	<10	800
Minimum	6.6	6.0	4	2.9	0.27	1	0.94	0.16	0.07	0.05	1.25	<10	<10	50
Maximum	27.8	8.4	72	9.0	1.76	18	2.24	1.09	9.22	0.49	10.59	119	22	67,000
Mean	17.4	7.4	13	6.0	0.90	5	1.45	0.45	5.46	0.16	7.07	20	11	708

ND = No Data

TABLE 4: PHOSPHORUS LOAD UPSTREAM AND DOWNSTREAM OF LEMONT WATER RECLAMATION PLANT COMPARED TO PROJECTED DOWNSTREAM LOAD FOLLOWING EXPANSION

Date	Phosphorus Load Upstream Lemont WRP (lbs)	Phosphorus Load Downstream Lemont WRP (lbs)	Projected Phosphorus Load Downstream Lemont WRP (lbs)
02/21/06	7,158	8,680	8,787
03/20/06	10,304	8,563	8,678
04/17/06	46,073	40,775	40,919
05/15/06	10,789	13,999	14,098
06/19/06	6,990	6,254	6,352
07/17/06	11,452	9,386	9,485
08/21/06	8,890	10,313	10,415
09/18/06	7,963	9,968	10,056
10/16/06	7,628	6,184	6,290
11/20/06	6,681	7,056	7,151
12/18/06	6,427	7,377	7,479
01/16/07	14,332	15,815	15,898
02/20/07	5,836	9,155	9,251
03/19/07	11,286	12,293	12,368
04/16/07	8,458	8,973	9,051
05/21/07	4,562	4,427	4,524
06/18/07	15,649	16,765	16,878
07/16/07	9,671	9,905	10,014
08/20/07	76,433	80,550	80,619
09/17/07	8,869	8,478	8,600
10/15/07	17,272	15,482	15,579
11/19/07	14,847	13,507	13,606
01/22/08	11,819	11,251	11,329
02/19/08	8,129	10,024	10,110
03/17/08	16,678	16,702	16,799
04/21/08	7,228	6,601	6,672
05/19/08	7,619	7,124	7,197
06/16/08	9,931	9,414	9,503
07/21/08	26,309	24,452	24,548
08/18/08	20,526	15,399	15,499
09/15/08	40,709	36,640	36,692
10/20/08	15,185	15,224	15,321
11/17/08	8,983	8,779	8,884
12/15/08	8,212	8,366	8,453
Mean	14,674	14,526	14,621
Standard Deviation	14,166	14,035	14,032