Annual Cost Estimation for Water Sample Analysis

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To meet public demand for better water quality, provincial and federal agencies initiated monitoring programs for regular drinking water sampling and analysis that focused on water quality indicators such as pH, turbidity, conductivity, sediments, nutrients, major ions and metals, alkalinity, suspended solids, and sometimes pesticides and bacteria. Monitoring was also used to assess the effects of these contaminants on fish and wildlife.

Without adequate monitoring data and full knowledge of the hydrologic component of a particular system, scientists, managers and decision-makers can only speculate about water quality problems, probable causes, likely consequences, and the efficiency of management measures and policies meant to protect and maintain high water quality.

I. Factors influencing the cost for water sampling analysis

Monitoring is often uniquely tailored to specific issues, the area of surveillance, and financial and time constraints. It usually involves the periodic sampling of waters over a large area and over a length of time and the analysis of a wide variety of water quality parameters. It is valuable for identifying potentially detrimental changes from a system's natural conditions over time. For the purpose, water quality samples are collected and analyzed in the lab.

The cost of monitoring is quite high, involving

- network design and management (installation of monitoring stations and plan of routine operation)
- purchase of sampling equipment (e.g., sample kits, pumps and bottles)
- operation of water sampling
- sample preparation, transportation, and storage
- laboratory analysis
- training of specialized staff
- costs of data processing
- interpretation and reporting of results.

To put it simply, the total cost for water sample analysis is divided into two components, direct cost and complementary (supporting system) cost. Thus, the cost can be obtained by the following equation:

$$C=A+B \qquad (1)$$

In which:
C---Annual total cost for water monitoring
A---direct cost for water sampling analysis in a lab, which is calculated through the following formula (2)
B---cost in supporting the analysis that can be obtained from formula (3)

Direct cost of water quality analysis:

$$A=N\times S\times (P_iU_i) \qquad (2)$$

In which:
N---number of water monitoring stations
S---frequency of water quality samples taking from each station per year
P_i---parameters of ODWS
U_i---unit price corresponding to parameter i in ODWS list
i----number from 1 to 174 (186, if ONT Regulation 459/00 applied in the estimation)

And:

$$B=E+W+K+T \qquad (3)$$

In which:
E---represents the expenses in collection of samples
W---cost in preparation of assessment report and study if necessary
K---represents cost in sampling equipment, such as sample kits
T---cost for training

The following discussion is focused on the cost of A, direct cost for water sampling analysis.

II. Parameters of water quality sample analysis

There are several guidelines, standards and regulations with different requirements on water quality sampling parameters. The Ontario Drinking Water Protection Regulation 459/00 has listed 186 parameters for water quality analysis. Ontario Drinking Water Standard includes 174 parameters. These two standards have different parameter groups. Based on analysis of data, parameters from ODWS should be applied in the cost estimation of water quality sample analysis for the reasons:

1. It is now and before used by most labs for water sample analysis and water quality monitoring;
2. The "Part Two: Report on the Commission of the Walkerton Inquiry" is focused specifically on drinking water quality as ODWS does; ONT Reg. 459/00 covers both surface water and drinking water quality, it is difficult to separate parameter group for surface water and drinking water quality. Besides, it is not necessary in the paper.

Therefore, in the estimation of annual water quality sample analysis, the required water quality monitoring parameters by the Ontario Drinking Water Standard is applied. The detailed list is showing in Appendix II.

III. Determination of unit price for each water sample

The extracted information of the unit price of some parameters for water sample analysis in a private accredited lab is shown in Appendix I. The price for water test

package[1] is used instead of using a unit price of each parameter for an accumulative calculation because more than two thirds of unit price for individual parameters are unavailable. The labs for water quality analysis are only conducting around 41 parameters under ODWS.

Package test: Analysis as per Ontario Drinking Water Standard

Cost: $3,430.00[2] (parameters such as temperature, chloramines etc are not included as these parameters are tests that must be completed at the sampling site.)

Total Cost (GST incl.): $3,867.50[3]

This total cost is for one monitoring network only for one sampling period for all parameters under ODWS.

IV. Provincial Water Quality Monitoring Network

There are several sources regarding the total number of drinking water quality monitoring stations in Ontario. According to Anne Mitchell of CIELAP, Professor Lewis Molot of York University and the authors of *Liquid Assets----Monitoring Water Quality in Ontario*, December 2001, there are 240 stations under the Provincial Water Quality Monitoring Network[4]. This data was applied as the baseline for the approximate current cost of water analysis.

V. Frequency for water sampling

The frequency for drinking water quality sampling has always been 8-10 times per year since the Provincial Water Quality Monitoring Network established in 1964. In the future, frequency of sampling and the corresponding lab analysis might increase to approximately 26 times a year, equivalent to biweekly sampling and testing.

VI. Cost Summary

Therefore, we come to the estimation of approximate annual cost:

$A=N\times S\times (P_iU_i)$

In which: N=240 stations

S=10--26 frequency of sampling (10 times a year before and now, 26 times per year in the future)

(P_iU_i)=3867.50 price of package analysis

A=$9,282,000---24,133,200 (per year)

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[1] Water test package price is the total amount set by the lab for certain parameters, not for individual parameter.

[2] Data source: fax from Maxxam Analytics Inc. 16/07/2002.

[3] Data source: Maxxam Analytics Inc.

[4] Lewis Molot, Karen Clark, Daniella Molnar, Jillian Henderson and Jenna Greatorex: Liquid Assets---- Monitoring Water Quality in Ontario, December 2001. p7-p8.

For more accurate results of drinking water quality monitoring and control, it is assumed an increase in monitoring stations is necessary, automatically increasing costs. If a unit price of each parameter is applied for cost calculation, the accumulative figure of total cost will be more accurate, and will surely be higher than the results above.

There are approximately 41 parameters analyzed currently by MOE for Provincial Water Quality Stations, which are listed in Appendix II. The total cost of analysis for these 41 parameters is $389.25[5], and the detailed unit price for each individual parameter is shown in appendix II[6].

Currently the approximate expenditure A_c in water sample analysis is calculated as follows:

$$A_c = N_c \times S_c \times (P_i U_i)_c$$

In which,

N_c is the number of water quality monitoring stations currently in operation

S_c is the freuqency of collecting and analyzing water samples

$(P_i U_i)_c$ is the total price for current 41 parameter analysis

Thus,

$$A_c = 240 \times 10 \times 389.25 = \$934,200$$

Therefore, increased cost:

$$\Delta A = 240 \times 10 \times (3867.50 - 389.25) \text{-----} 240 \times 26 \times (3867.50 - 389.25)$$

$$= \$8,347,800 \text{-----} \$21,704,280$$

The results demonstrate an increased investment of $ 8 - 22 million is necessary each year for direct sampling and analysis of water quality monitoring in Ontario when all parameters under ODWS are covered and sampling and testing frequency goes up to around 26 times per year. It does not include the cost for training, data interpretation, report outputs and facility management. Currently the cost in water sample analysis is only 4% to 11% of that needed presently to cover all parameters and in the future to increase sampling and testing frequency.

[5] Data source: fax from Maxxam Analytics Inc. 31/07/2002.
[6] Data source: Maxxam Analytics Inc.

Appendix I Comparison of water quality parameters (Ontario Regulation 459/00) and ODWS

Table 1 Agreements of ONT Reg. 459/00 and ODWS on water quality parameters

No.	Parameter group	Parameter	OR 459/00	ODWS
1	Carbamates	Aldicarb	X	X
2		Carbofuran	X	X
3		Bendiocarb	X	X
4		Carbaryl	X	X
5		Triallate	X	X
6	Chlorinated Organics	Heptaclor	X	
7		Heptachlor epoxide	X	
8		Heptachlor+Heptachlor Epoxide	X	X
9		Aldrin	X	
10		Dieldrin	X	
11		Aldrin+Dieldrin	X	X
12		pp-DDE	X	
13		Trifluralin	X	X
14		Lindane	X	X
15		a-chlodane	X	
16		g-chlodane	X	
17		Oxychordane	X	
18		Chlordane (Total)	X	X
19		Op-DDT	X	
20		pp-DDT	X	
21		pp-DDD	X	
22		(DDT)+Metabolites	X	
23		Methoxychlor	X	X
24		Polychlorinated Biphenyls(PCBs)	X	X
25	Chlorophenols and Phenoxyacid Herbicides	2,4-dichlorophenol	X	X
26		2,4,6-trichlorophenol	X	X

27		2,3,4,6-tetrachlorophenol	X	X
28		Pentachlorophenol	X	X
29		Dicamba	X	X
30		Bromoxynil	X	X
31		2,4-dichlororpheno-xyacetic acid(2,4-D)	X	X
32		2,4,5-trichloropheno-xyacetic acid(2,4,5-T)	X	X
33		Dinoseb	X	X
34		Pecloram	X	X
35		Diclofop-methyl	X	X
36	Dioxin and Furan	Octachlorofuran	X	
37		Octachlorodioxin	X	
38		2378-tetrachlorofuran	X	
39		2378-tetrachlorodioxin	X	
40		12378-pentachlorofuran	X	
41		23478-pentachlorofuran	X	
42		12378-pentachlorodioxin	X	
43		123478-hexachlorofuran	X	
44		123678-hexachlorofuran	X	
45		234678-hexachlorofuran	X	
46		123789-hexachlorofuran	X	
47		123478-hexachlorodioxin	X	
48		123678-hexachlorodioxin	X	
49		123789-hexachlorodioxin	X	
50		1234678-heptachlorofuran	X	
51		1234789-heptachlorofuran	X	
52		1234678-heptachlorodioxin	X	
53		Dioxin and Furan	X	X
54	Diquat and Paraquat	Diquat	X	X
55		Paraquat	X	X
56	Inorganic Nutrients	Nitrate+Nitrite(as nitrogen)	X	X

57		Nitrite (as nitrogen)	X	X
58		Nitrate (as nitrogen)	X	X
59		Ammonia	X	
60		Ammonia Nitrogen	X	
61		Ammonia + Ammonium (N)	X	
62		Nitrogen-Kjeldahl (N)	X	
63		O-Phosphate	X	
64		4AAP-Phenolics	X	
65		Phosphorus	X	X
66	Inorganics-General	Sodium	X	X
67		Fluoride	X	
68		Cyanide	X	X
69		Turbidity	X	X
70		Nitrilotriacetic acid (NTA)	X	X
71		PH	X	X
72		Alkalinity	X	X
73		Hardness	X	X
74		Color	X	X
75		Aluminum Residual	X	
76		Bromide	X	
77		Chloride	X	X
78		Conductivity	X	
79		Dissolved Organic Carbon	X	X
80		Free Chlorine Resideual	X	
81		Sulphide	X	X
82		Organic Carbon	X	
83		Silicon; Reactive silicate	X	
84		Solides (Total Dissoved)	X	X
85		Sulphate	X	X
86	Inorganics-Mercury	Mercury	X	X

87	Inorganics-Metals	Copper	X	X
88		Zinc	X	X
89		Cadmium	X	X
90		Chromium	X	X
91		Lead	X	X
92		Iron	X	X
93		Manganese	X	X
94		Aluminum	X	X
95		Barium	X	X
96		Uranium	X	X
97		Boron	X	X
98		Arsenic	X	X
99		Selenium	X	X
100		Calcium	X	X
101		Cobalt	X	X
102		Magnesium	X	
103		Nickel	X	
104		Potassium	X	
105		Silver	X	
106		Vanadium	X	
107	Microbiological-Heteroterophic Plate Count	Membrane filtration: HPC	X	
108		Membrane filtration: HPC	X	
109		Spread plate: HPC	X	
110		Spread plate: HPC	X	
111		Pour plate: HPC	X	
112		Pour plate: HPC	X	X
113	Microbiological Membrane Filtration	Total Coliform	X	
114		Membrane filtration: Total Coliform	X	
115		Membrane filtration: Total Coliform	X	
116		Membrane filtration: Total Coliform background	X	

117		Membrane filtration: Total Coliform background	X	
118		Membrane filtration: E. coli	X	
119		Membrane filtration: E. coli	X	
120		Membrane filtration: Fecal coliforms	X	
121		Membrane filtration: Fecal coliforms	X	
122		E.coli	X	
123	Microbiological-Presence/Absence	Presence/Absence: Total coliform	X	
124		Presence/Absence: E. coli	X	X
125		Presence/Absence: Fecal coliforms	X	
126	Microiological-MPN	MPN: Total coliform	X	
127		MPN: E. coli	X	
128		MPN: Fecal coliforms	X	
129	Operational Parameter-Others	Temperature	X	X
130		Odour/Taste	X	X
131		Methane	X	X
132		Chloramines	X	X
133		Residual chlorine	X	
134	Organics-General	Nitrosolimethylamine (NDMA)	X	X
135		Benzo(a)pyrene	X	X
136		Glyphosate	X	X
137		Diuron	X	X
138		Geosmin	X	
139	Organophosphorus Pesticides	Dimethoate	X	X
140		Azinphos-methyl	X	X
141		Malathion	X	X
142		Parathion	X	X
143		Doazinon	X	X
144		Phorate	X	X
145		Temephos	X	X
146		Terbufos	X	X

147		Chlorpyrifos	X	X
148	N-Containing Herbicides	Cyanazine	X	X
149		Atrazine	X	
150		Metribuzin	X	X
151		Prometryne	X	X
152		Simazine	X	X
153		Metolachlor	X	X
154		Alachlor	X	
155		De-ethylaated atrazine	X	
156		Atrazine + N-dealkylated metabolites	X	X
157	Volatile Organics	Vinyl Chloride	X	X
158		1,1-dichloroethylene (vinylidene chloride)	X	X
159		Dichloromethane	X	X
160		Chloroform	X	
161		1,2-dichloroethane	X	X
162		Carbon tetrachloride	X	X
163		Benzene	X	X
164		Trichloroethylene	X	X
165		Bromodichloromethane	X	
166		Toluene	X	X
167		Dibromochloromethane	X	
168		Tetrachloroethylene (perchloroethylene)	X	X
169		Monochlororbenzene	X	X
170		Ethylbenzene	X	X
171		M/p-xylene	X	
172		Bromoform	X	
173		o-xylene	X	
174		1,4-dichlorobenzene	X	X
175		1,2-dichlorobenzene	X	X
176		Trihalomethanes (total)	X	X

177		Xylene: total	X	X
178	Radiological Standards	Carbon-14	X	X
179		Gamma	X	
180		Strontium-90	X	X
181		Tritium	X	X
182		Cesium 137	X	X
183		Gross Alpha	X	
184		Gross Beta	X	
185		Iodine 131	X	X
186		Radium 226	X	X
	Additional parameters from ODWS			
1	Chemical/Physical Standards and Objectives	Alachlor		X
2		Dichlorodiphenyltrichloroethane		X
3		Picloram		X
4	Microbiological Standards-Health Related	General Bacterial Population		X
5	Radionuclide Standards-Health Related: Natural Radionuclides	Beryllium-7		X
6		Bismuth-210		X
7		Lead-210		X
8		Radium-224		X
9		Radium-228		X
10		Thorium-228		X
11		Thorium-230		X
12		Thorium-232		X
13		Thorium-234		X
14		Uranium-234		X
15		Uranium-235		X
16		Uranium-238		X
17	Radionuclide Standards-Health Related: Artificial Radionuclides	Americium-		X
18		Antimony- [50 MAC(Bq/L)]		X
19		Antimony- [40 MAC(Bq/L)]		X

20		Antimony- [100 MAC(Bq/L)]		X
21		Barium-140		X
22		Bromine-82		X
23		Calcium-47		X
24		Cerium-141		X
25		Cerium-144		X
26		Cesium-131		X
27		Cesium-134		X
28		Cesium-136		X
29		Chromium-51		X
30		Cobalt-58		X
31		Cobalt-60		X
32		Gallium-67		X
33		Gold-198		X
34		Indium-111		X
35		Iodine-125		X
36		Iodine-129		X
37		Iron-55		X
38		Iron-59		X
39		Manganese-		X
40		Mercury-197		X
41		Mercury-203		X
42		Molybdenum		X
43		Neptunium-		X
44		Nibium-95		X
45		Plutonium- [0.3 MAC(Bq/)]		X
46		Plutonium- [0.2 MAC(Bq/)]		X
47		Plutonium- [10 MAC(Bq/)]		X
48		Rhodium-105		X
49		Rubidium-81		X

50		Rubidium-86		X
51		Ruthenium- [100 MAC(Bq/)]		X
52		Ruthenium- [10 MAC(Bq/)]		X
53		Selenium-75		X
54		Silver-110left message		X
55		Silver-111		X
56		Strontium-85		X
57		Strontium-89		X
58		Sulphur-35		X
59		Technetium-99		X
60		Technetium-		X
61		Tellurium-		X
62		Tellurium-132		X
63		Thallium-201		X
64		Ytterbium-169		X
65		Yttrium-90		X
66		Yttrium-91		X
67		Zinc-65		X
68		Zirconium-95		X
69	Chemical/Physical Objectives-Not Health Related	Organic Nitrogen		X

The table shows that there is quite difference of parameter list for water sample analysis between Ontario Water Quality Protection Regulation 459/00 and Ontario Drinking Water Standards. There are 81 parameters of OWQPR missed in ODWS, 69 parameters from ODWS not listed in OWQPR. There are totally 105 parameters overlayed by both standards. It looks that ODWS has paid much attention on artificial radionuclides: 52 parameters out of the 69 are located in this category, accounting for 75.5%.

Appendix II Price-List of Parameters Monitoring Currently

Table 2 List of parameters and Unit Price

No.	Parameter	Unit Price ($)
1	Alkalinity, Unfiltered Total	12.00
2	Aluminum, Unfiltered Total	45.00
3	Barium, Unfiltered Total	*
4	Berylium, Unfiltered Total	*
5	Bod, 5 Day, Total Demand	26.00
6	Calcium, Unfiltered Total	*
7	Cadmium, Unfiltered Total	*
8	Chloride, Unfil. Reac	17.50
9	Chemical Oxygen Demand	20.00
10	Conductivity, 25c	6.00
11	Cobalt, Unfiltered Total	*
12	Chromium, Unfiltered Total	*
13	Copper, Unfiltered Total	*
14	Carbon, Dissolved Inorganic	17.50
15	Carbon, Dissolved Organic	17.50
16	Escherichia Coli Mf	15.50
17	Iron, Unfiltered Total	*
18	Fecal Streptococcus Mf	17.00
19	Hardness, Total	16.00
20	Magnesium, Unfiltered Total	*
21	Manganese, Unfiltered Total	*
22	Molybdenum, Unfiltered Total	*
23	Nickel, Unfiltered Total	*
24	Ammonium, Total Unfil. Reac	16.00
25	Nitrite, Unfiltered Total	12.00
26	Nitrates, Total, Unfil. Reac	17.00
27	Nitrogen, Tot, Kjeladahl/Unf. Rea	17.50
28	Lead, Unfiltered Total	15.00
29	PH	5.50
30	Phenolics, Unfiltered Total	16.00
31	Phosphate, Filtered Reactive	12.00
32	Phosphorus, Unfiltered Total	16.00
33	Pseudomon. Aeruginosa Mf	16.25
34	Residue, Filtered	12.00
35	Residue, Particulate	12.00
36	Residue, Total	12.00
37	Silicates, Unfiltered Reactive	*
38	Strontium, Unfiltered Total	*
39	Titanium, Unfiltered Total	*
40	Vanadium, Unfiltered Total	*
41	Zinc, Unfiltered Total	*
Total		389.25

* Included with Aluminum.

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