RE: WATER TREATMENT FOR THE CITY'S WATER SUPPLY – PHASE III

For submission to: Standing Policy Committee on Public Works

Original report signed by: Barry D. MacBride, P.Eng.
Director
Water and Waste

Report date: May 30, 2002

In camera item: No

Recommendation(s):

1. That the baseline water treatment process approved by Council be amended to include ultra violet (UV) light disinfection.
2. That the schedule for implementation of water treatment approved by Council be amended to facilitate staged implementation, with construction of a UV disinfection facility to be operational in 2004, construction of a chloramination facility to be operation in 2005 and construction of the balance of the water treatment plant to be operational in 2007.
3. That membrane filtration not be considered for water treatment in Winnipeg, due to the high cost of the technology.

REPORT SUMMARY

Key Issues:

Implications of the Recommendation(s):

General Implications

	None
	For the organization overall and/or for other departments
X	For the community and/or organizations external to the City of Winnipeg
	Involves a multi-year contract

Comment:

- Early construction of UV disinfection will reduce the risk of pathogens in the water supply, in advance of construction of full water treatment.
- Early construction of chloramination will reduce disinfection byproducts slightly in the water supply, in advance of full water treatment.
- The other benefits of water treatment (multiple barriers, organics removal, taste and odour) will be delayed one year until the full water treatment plant is in-service.

- Full water treatment will improve the overall security of the water supply, improve customer satisfaction and enhance the economic development capabilities of the community. Experience elsewhere demonstrates conclusively the severe consequences of a waterborne disease outbreak, which include human health impacts, economic losses, and loss of public confidence.

Policy implications

	No
X	Yes

Comment:

- Public Health: Advances health benefits related to pathogen control and reduced disinfection byproducts, but delays full water treatment by one year.

Financial Implications

	Within approved current and/or capital budget
X	Current and/or capital budget adjustment required

Comment:

- The staged water treatment program including UV disinfection proposed herein has a total capital budget of $214 Million.
- Delaying the in-service date from 2006 to 2007 will result in savings in operating and debt servicing costs, which offset the additional capital cost and allow the project to be implemented without increasing rates.

REPORT

RECOMMENDATION(S):

1. That the baseline water treatment process approved by Council be amended to include ultra violet (UV) light disinfection.
2. That the schedule for implementation of water treatment approved by Council be amended to facilitate staged implementation, with construction of a UV disinfection facility to be operational in 2004, construction of a chloramination facility to be operation in 2005 and construction of the balance of the water treatment plant to be operational in 2007.
3. That membrane filtration not be considered for water treatment in Winnipeg, due to the high cost of the technology.

REASON FOR THE REPORT:

Council requested that the Administration report back on the review of emerging water treatment technologies such as ultraviolet light disinfection and membranes.

HISTORY:

1993 Council approved the creation of the Water Treatment Reserve Fund to cash finance a portion of the cost of a water treatment plant.

1999 On May 26, Council approved a process for public consultation on whether or not to proceed with a water treatment plant.

1999 On October 6, a Council Seminar was held to present a summary of water quality guidelines, public health risks and consequences, recommended water treatment process, cost and financing of a water treatment plant.

1999 October 21 & 28, Special Meetings of Executive Policy Committee (EPC) were held to hear from the public on the need to construct a water treatment plant.

2000 On November 12, Council adopted the following recommendations:

1. *The City proceed with treatment of the water supply as described herein.*
2. *Design and construction activities be undertaken so that the water treatment plant be operational in the year 2006.*
3. *That the water treatment process as identified through the pilot testing and described herein be adopted as the baseline process for comparison to alternatives and new technologies.*
4. *The Administration:*
   a) *Investigate and report on emerging technologies such as ultraviolet disinfection and membranes;*
   b) *Investigate and report on alternative project delivery strategies;*
   c) *Prepare documents in support of any application by Council for Federal and Provincial funding.*

DISCUSSION:

The water treatment proposal approved by City Council was designed to provide protection against C*ryptosporidium* and to reduce the level of disinfection by-products to meet current and future Canadian drinking water guidelines. The proposed treatment plant would also improve the taste and odour associated with algae in the water.

This report provides an update concerning the development of the water treatment plant pursuant to the recommendations Council adopted report of November 12, 2000 expect for items 4b and 4c. Items 4b (alternative service delivery) and 4c (application for Federal and Provincial funding) will be dealt with later in separate reports.

New Developments Concerning Water Treatment:

A number of developments have occurred since the completion of the pilot test 1997, which formed the foundation of the selected baseline water treatment process recommended in November 2000. They are:

- Additional water industry research on the application of ozone in cold water has resulted in a change in the design standards (a significant dose increase) for C*ryptosporidium* inactivation. The estimated cost of the ozone system would need to be increased by $22 Million to meet the new requirement and the annual operating cost would increase $0.5 million. The use of UV disinfection for *Cryptosporidium* inactivation will avoid this cost increase.
- The *Guidelines for Canadian Drinking Water Quality* continue to become more stringent. The Federal-Provincial-Territorial Subcommittee on Drinking Water has proposed reducing the Turbidity guideline from 1.0 NTU to 0.3 NTU. Full water treatment will be required in order to meet this guideline. This change was anticipated in setting the pilot testing goals.
- Calgon Carbon Corporation has obtained a Canadian patent for the application of UV disinfection for the inactivation of *Cryptosporidium*. Under the existing patent the owner of a water treatment facility using UV disinfection is required to pay a royalty for the use of the technology. This royalty fee could amount to $400,000 annually for Winnipeg. Although it is uncertain as to whether the patent will withstand legal challenges, this cost has been carried in the economic analyses of all treatment options that use UV disinfection.
- The Department undertook a survey of customers in 1999. This survey identified that customers were concerned about drinking water safety and wanted more information concerning water quality. The survey was repeated in 2002 and the data indicates that satisfaction with water quality (those rating water quality as good or excellent) fell 7% over the three years to 57%. While unrelated to the recommendations herein, the Department is responding to our customers' desire for more information about water quality by issuing our first Winnipeg Water Quality Report to every household and business in Winnipeg during the week of June 24, 2002.

Emerging Water Treatment Technologies:

Two emerging water treatment technologies, UV disinfection and membrane filtration, were further studied for application in Winnipeg. The costs and benefits of all process schemes that were developed as a result of this research were compared to the baseline process recommended in November 2000.

UV Disinfection and Alternate Disinfectants to Minimize Disinfection By-Products:

Research relating to both UV disinfection and of formation of disinfection by-products of Shoal Lake unfiltered water was carried out under the auspices of a collaborative research project administered by the AWWA Research Foundation (AWWARF) for the City of Winnipeg. The total budget for the research was $517,905 U.S. Because it was believed that this research would benefit the water industry in general, AWWARF provided direct funding in the amount of $125,965 U.S. in support of the research, and researchers provided in-kind

support of $125,965 US. As a result, Winnipeg's direct financial contribution to the research was limited to $125,965 U.S., and the Federal Green Municipal Enabling Fund contributed $90,000 Canadian in support of Winnipeg's efforts.

With respect to UV disinfection, the research has demonstrated that UV disinfection is effective for pathogen control (*Giardia* and *Cryptosporidium*) for unfiltered Shoal Lake water.

The AWWARF research concerning alternative disinfectants that could be used in conjunction with UV disinfection of unfiltered Shoal Lake water demonstrated that disinfection of the water delivered to distribution system using chloramines is viable and will reduce THMs to just below the current Canadian drinking water guideline.

Membrane Filtration:

The second treatment technology studied was membrane filtration. The cost of membrane filters is declining as they become more popular. Raw water characteristics are critical to the successful operation of the membrane. The high levels of natural organics in Shoal Lake raw water require an extensive pre-treatment system, similar to what was selected as part of the baseline treatment process. A number of possible membrane systems were priced and compared to the baseline capital and operating costs using an evaluation model. Based upon this evaluation, it has been concluded that a water treatment plant based on a membrane filter system, estimated at $272 million capital and $26 million operating and maintenance, would not be as cost effective for Winnipeg as the baseline process.

Proposed Revisions to the Baseline Water Treatment Process to Include UV Disinfection:

An extensive testing program was carried out to develop a baseline water treatment process to meet Winnipeg's water quality goals. A pilot water treatment plant was constructed and operated to test various treatment processes and to optimize treatment efficiency for Shoal Lake water. The baseline water treatment process is shown in Appendix 1 and includes coagulation, dissolved air flotation, ozone, filtration, and disinfection using chloramines.

It has now been demonstrated that UV disinfection is effective for Shoal Lake water, and that it is more economical to use UV disinfection for pathogen control than to increase the capacity of the ozone step.

Accordingly, it is recommended that UV disinfection be integrated into baseline water treatment process and that all future water treatment alternatives will be evaluated against the baseline process with UV disinfection. In this process train, UV disinfection is used for pathogen control, and it is not necessary to increase the size of the ozone step to inactivate *Cryptosporidium*. Ozone is still required for virus control, and will significantly improve taste and odour and improve filter rates at minimal cost.

Capital Cost Impacts:

The following project capital costs include: design, engineering, construction, environmental approvals, inflation, contingency and finance/administration charges.

- In 1999, the project cost of a water treatment plant was estimated at $204 million.
- The new cold water ozone disinfection requirements would increase this cost to $226 million.
- UV disinfection is a cost effective alternative to expanding the ozone capacity to achieve the same disinfection requirements. The capital cost of full treatment including this process is estimated at $214 million.

Operating Cost Impacts:

Operating and maintenance costs include an allowance for property taxes and inflation to 2006. In 1999, the annual operating and maintenance costs were estimated at $12 million. The UV disinfection annual operating and maintenance are estimated at $0.75 million for a new total of $12.75 million.

Recommended Staging:

In 1999, the financial plan and water rate model called for construction of the water treatment plant to commence in 2004 with an in-service date of 2006.

The additional investigation related to emerging water treatment technologies has identified a unique opportunity for the City to phase in water treatment. This strategy can enhance public health by providing some elements of water treatment in advance of full treatment and provide the required funding to deal with the increased cost of adding UV disinfection to the baseline water treatment process.

The recommended strategy is:

- Construct a UV disinfection facility in advance of the full water treatment plant to enhance pathogen control to protect public health.
- Convert the water distribution system to use chloramines instead of chlorine to reduce the current level of disinfection byproducts, after the UV disinfection facility is commissioned but prior to constructing the full water treatment plant.
- Continue to accumulate funds in the Water Treatment Plant Reserve by delaying the full water treatment plant in-service date by one year to late 2007, to permit funding of the UV disinfection facilities.

Impact on Capital Budget Estimates and Water Rates:

On December 31, 2001, there was $53 million in the Water Treatment Plant Reserve.

The capital estimates that are currently being carried in the Council approved budget documents are shown in Table 1. The capital budget impact of the proposed phased water treatment strategy that would delay the in-service for full treatment by one year is illustrated in Table 2.

Table 1: Existing Water Treatment Program Budget ($000)

WTP	Previous Approved	2002	2003	2004	2005	2006	2007	Total
Reserve	8,000	6,000	26,000	50,000	12,000			102,000
Debt				34,000	68,000			102,000
Total								204,000

Table 2: Proposed Water Treatment Program Budget ($000)

WTP	Previous Approved	2002	2003	2004	2005	2006	2007	Total
Reserve	8,000	6,000	6,000	26,000	50,000	16,000		112,000
Debt					34,000	68,000		102,000
Total								214,000

The impact of adding UV disinfection and delaying construction of full water treatment on water rates is estimated to be cost neutral. Cost savings from delayed debt financing and operating costs will offset the additional reserve contributions needed to fund the UV disinfection facility.

FINANCIAL IMPACT:
The following financial impact statement for this project has been prepared in accordance with the recommendation adopted by Council on December 13, 2000.

Financial Impact Statement — Date: May 30, 2002

Project Name: — **First Year of Program** 2002

Water Treatment Project

	2002	2003	2004	2005	2006
Capital					
Capital Expenditures Required	$ 6,000	$ 6,000	$ 26,000	$ 84,000	$ 84,000
Less: Existing Budgeted Costs	6,000	26,000	84,000	80,000	-
Additional Capital Budget Required	$ -	$ (20,000)	$ (58,000)	$ 4,000	$ 84,000
Funding Sources:					
Debt - Internal	$ -	$ -	$ -	$ -	$ -
Debt - External	-	-	-	34,000	68,000
Grants (Enter Description Here)	-	-	-	-	-
Reserves, Equity, Surplus	6,000	6,000	26,000	50,000	6,000
Other - Enter Description Here	-	-	-	-	-
Total Funding	$ 6,000	$ 6,000	$ 26,000	$ 84,000	$ 74,000
Total Additional Capital Budget Required	$ 10,000				
Total Additional Funding Required	$ 10,000				
Current Expenditures/Revenues					
Direct Costs	$ -	$ -	$ -	$ -	$ -
Less: Incremental Revenue/Recovery	-	-	-	-	-
Net Cost/(Benefit)	$ -	$ -	$ -	$ -	$ -
Less: Existing Budget Amounts	-	-	-	-	10,000
Net Budget Adjustment Required	$ -	$ -	$ -	$ -	$ (10,000)

Additional Comments: By delaying the operation of the Water Treatment Plant by one year, from 2006 to 2007, the reduction in current operating costs will directly offset the additional capital budget. Previously Approved Capital = $8.0M

Moira L. Geer C.A.
Manager of Finance & Administration

In preparing the report, there was consultation with and concurrence by:

This Report Submitted By:

Department: Water and Waste
Division: Engineering
Prepared by: Duane Griffin
File No. 020-18-29-05-00

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APPENDIX 1

Question and Answers

Summary of Questions: **Page**

How has the Baseline Water Treatment Process Changed?

An extensive testing program was carried out to develop a baseline water treatment process to meet the water quality goals. A pilot water treatment plant was constructed and operated to test various treatment processes and to optimize treatment efficiency for Shoal Lake water.

The recommended water treatment process consisting of:

> Rapid mix + enhanced coagulation (ferric chloride) + flocculation + dissolved air flotation (DAF) + ozone (O_3) + biological activated carbon filtration (BAC) + monochloramine (NH_2C1) for secondary disinfection + water stabilization,

provided the most cost effective option on a life cycle cost basis, considering both capital and operating costs, while meeting established drinking water quality goals. This process will meet the current and foreseeable drinking water quality guidelines.

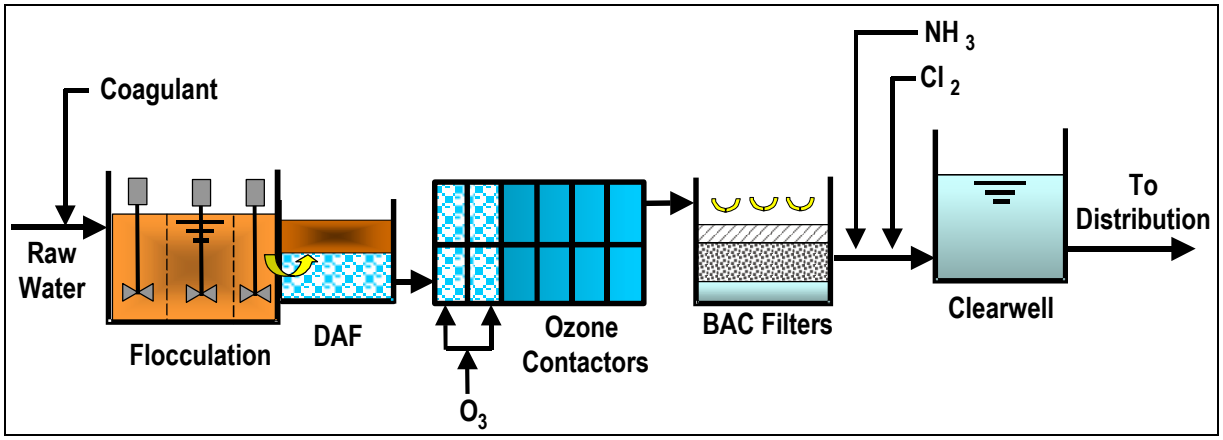

Figure 1: Baseline Water Treatment Process Schematic

Based on the additional study and pilot testing of UV disinfection, it is now being recommended that UV disinfection be integrated into the baseline water treatment process. All future water treatment alternatives would be evaluated against the baseline process with UV disinfection, as shown in Figure 2.

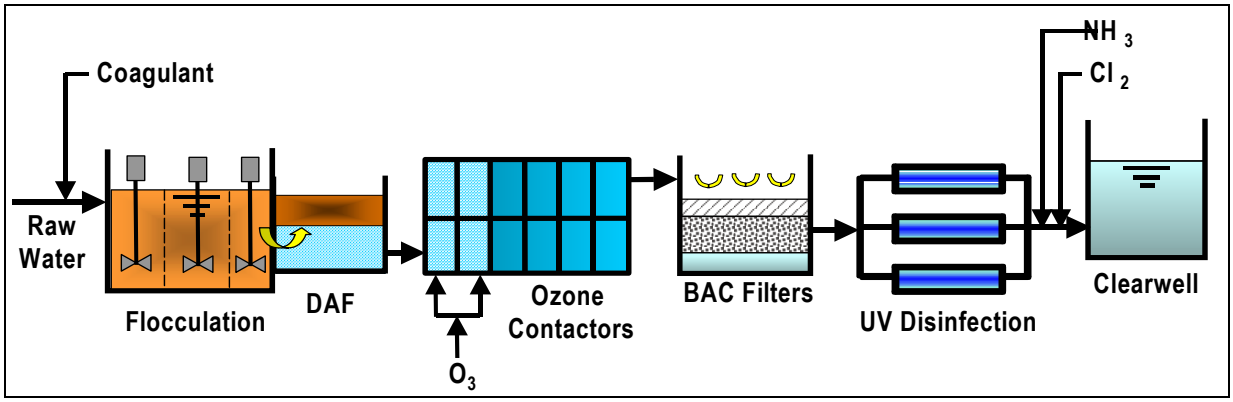

Figure 2: Baseline Water Treatment + UV Disinfection Schematic

What is the Water Treatment Project Schedule?

The design and construction of a water treatment plant is a significant undertaking. Using a phased implementation approach, the following work activities are necessary in order to bring the water treatment plant into service by late 2007.

2002 –2003:

- Design and construct a UV disinfection facility at Deacon.
- Conduct an alternative service study of the full range of project delivery options for water treatment and report to Council concerning the outcome of this study.
- Prepare appropriate documentation in support of any application for Federal and Provincial Funding.
- Conduct an Environmental Impact Assessment and prepare an application for approval of the project in conformance with Provincial regulation and City policy.
- Once the above studies are completed, the selected project delivery alternative will be implemented for water treatment.

2004-2005:

- Design and construct a chloramination facility at Deacon.

2005-2007:

- Design and construct the water treatment plant.

2007:

- Commission the water treatment plant to perform full treatment functions in the last quarter of 2007.

What is the Impact of Delaying the Water Treatment Project Beyond 2007?

Each year the water treatment project is delayed, the security of a multi-barrier water treatment process and the benefits of significantly improved taste and odour properties are deferred. The risk of a waterborne disease outbreak is low but the consequences are severe.

Delaying the project would lengthen the time to accumulate funds in the Water Treatment Plant Reserve, resulting in less long-term debt financing for the project. For each year the project is delayed, savings will be realized because long-term debt financing will be reduced and operating costs will not be incurred. For each year the project is delayed the saving in capital and operating net of inflation is estimated at $18 million.

Why is Additional Treatment Required Beyond UV Disinfection?

The treatment plant is required to provide physical barriers against pathogens that are not provided by disinfection by UV, chorine, and chloramines. Experience has shown that multiple barriers each with a low risk of failure are required to protect water quality. Disinfection is an important barrier but things can go wrong. For example UV effectiveness will be reduced during periods of high turbidity, which is exactly the time when the threat of pathogens is highest.

The need for multiple barriers is summarized in report on the North Battleford Water Inquiry:

> *"What the experts and the industry recommend with respect to the treatment of all surface water is a multi-barrier approach. The first barrier is watershed protection to ensure the best possible raw water source. The next barrier is optimization of the plant processes designed to achieve settlement of particulates and sediment in the raw water. The third barrier is maximization of the efficiency and monitoring of the filtration process which follows sedimentation. The final barrier is to ensure the water is adequately disinfected."*[1]

This need for multiple barriers is the reason that regulations in the United States require physical removal of pathogens by water treatment in addition to disinfection. This is also the reason for the proposed new turbidity guideline in Canada. Water treatment as proposed in Winnipeg will provide two physical barriers against pathogens, first in the coagulation, flocculation and dissolved air flotation steps and second in the biologically activated carbon filtration step. These steps combined with both UV and Ozone will provide the multiple barriers required.

In addition to providing the physical barrier, the water treatment plant will address the following:

- It is anticipated the trihalomethanes guideline will be made more stringent and full treatment will be required to meet the guideline.
- A turbidity guideline of 0.3 NTU has been proposed for Canada.
- UV disinfection does not improve the taste and odour of the existing Shoal Lake water.
- A secure, reliable, high quality treated water supply is an economic development asset.

Why is Ozone Required if UV Disinfection is Installed?

It has recently been determined that large ozone doses are required to inactivate *Cryptosporidium* in cold water temperatures. If the ozone system in the baseline process were expanded to meet the new ozone disinfection limit for *Cryptosporidium* inactivation, it would cost an additional $22 million. UV Disinfection is more cost effective for *Cryptosporidium* inactivation in cold water conditions than expanding the ozone process beyond what is proposed in the baseline water treatment process. However, ozone is still required. It is very effective at treating viruses and bacteria at low doses and provides significant taste and odour improvements. Ozone also improves filter rates, which reduces the size and capital cost of filters. Ozone and UV disinfection are complementary water treatment processes.

[1] Justice Robert D. Laing, Commissioner, Report of the Commission of the Inquiry into matters relating to the safety of the public drinking water in the City of North Battleford, Saskatchewan.

Why Not Use UV Disinfection to Inactivate Viruses?

Virus inactivation with UV disinfection requires very large UV doses, approximately five times the dose required to inactivate *Cryptosporidium* and *Giardia*. Chlorine disinfection or ozone disinfection is a much more cost-effective process. It is estimated that a stand-alone UV disinfection facility sized to inactivate viruses would cost $90 million, and the total water treatment project cost would increase to $289 million. Until full water treatment is implemented, THMs in the water cannot be significantly reduced.

Is Filtration Mandatory for Surface Water Supplies?

The current Canadian drinking water guidelines do not require filtration of surface water supplies. However, the Federal-Provincial-Territorial Subcommittee on drinking water recently issued a document titled "Turbidity in Drinking Water" for public comment. If the standards outlined in this document are adopted, all but the most isolated water supplies will require filtration. Watersheds that are entirely within the control of the drinking water supplier and are subject to an appropriate water shed management plan could be exempt, if the raw water quality was very high. Shoal Lake would not meet the turbidity criteria in the draft document.

Under the U.S. Safe Drinking Water Act, all drinking water obtained from surface water sources is to be filtered to remove microbial contaminants unless they can meet strict filtration avoidance criteria. For example, the City of New York has obtained a waiver to defer filtration based upon significant control over or ownership of the watershed and a number of specific long-term watershed protection measures for the watershed. These measures include: increasing owner ship of the watershed, expanding the waterfowl management program, funding sewage treatment upgrades within the watershed, expanding agricultural and forestry management programs, construction of a UV facility, and expanded customer information.

The Shoal Lake watershed is subject to regulation by multiple jurisdictions including the Federal Government, First Nations, Ontario, and Manitoba. Watershed management issues of the area are complex because of the diversity of the stakeholders and jurisdictions involved. In reviewing the watershed conditions imposed on the City of New York, it would be unrealistic to consider that the City of Winnipeg could avoid filtration by implementing a similar program.