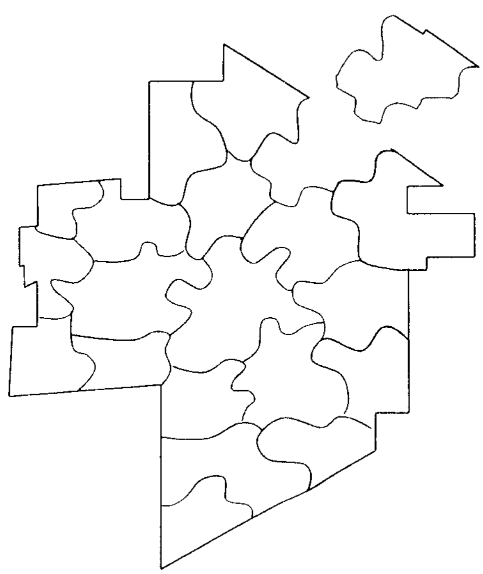
City of Winnipeg
Water and Waste Department

Combined Sewer Overflow Management Study

PHASE 2 Technical Memorandum No. 6

POTENTIAL CSO MANAGEMENT STRATEGIES



Internal Document by:

WARDROP Engineering Inc. and TetrES CONSULTANTS INC.

In Association With:

Gore & Storrie Limited and EMA Services Inc.

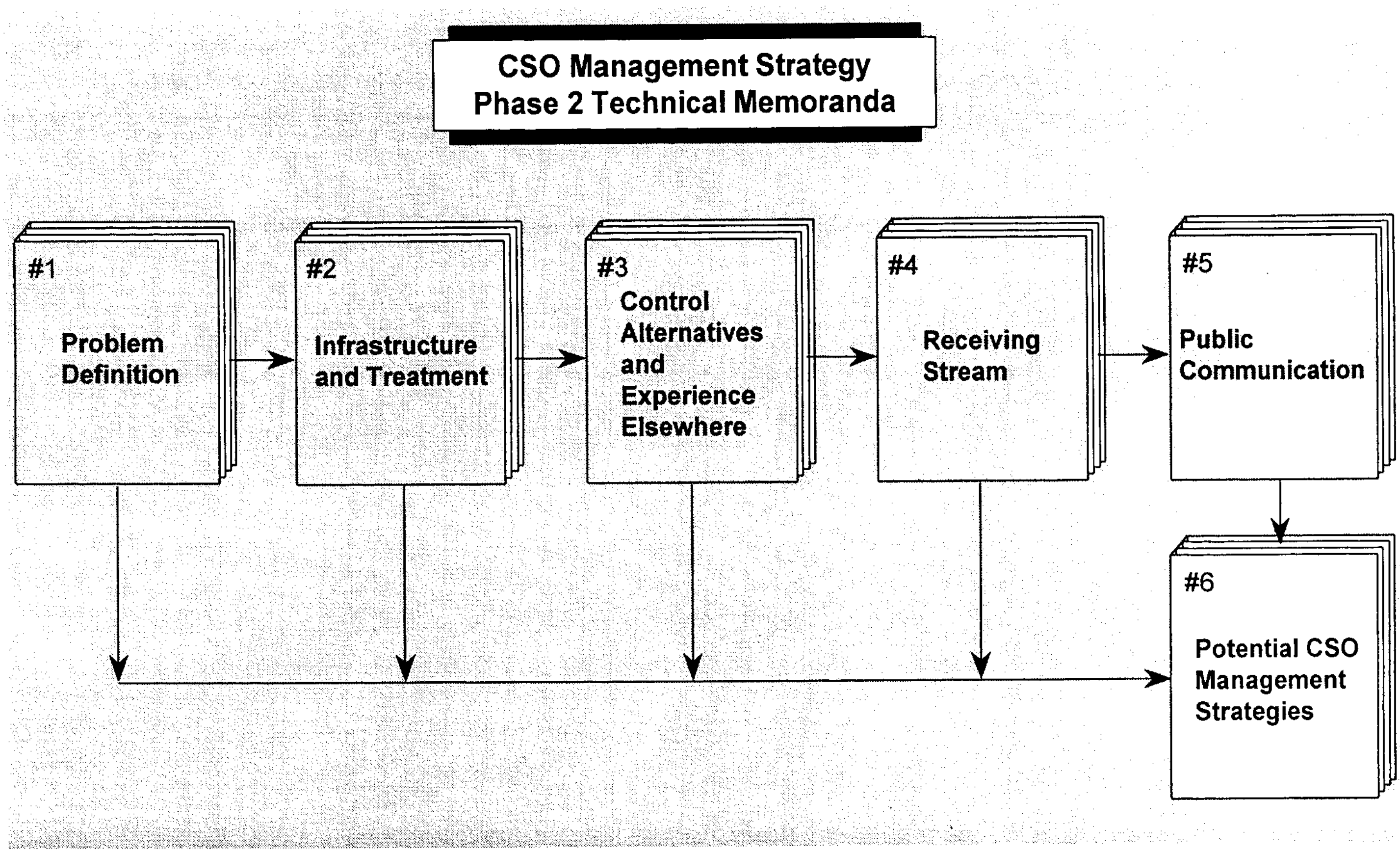
August 1995

August 29, 1995 8:41am

PREAMBLE

This Technical Memorandum (TM) is one of a series of TM's intended for internal discussion. It is not intended as a report representing the policy or direction of the City of Winnipeg.

This particular TM is part of a group of Phase 2 reports as shown in the schematic.



Each of the Phase 2 TMs draws on information developed in the prior Phase 1 TMs. In addition, the Phase 2 TMs document information and study analyses sequentially. Ideally, therefore, the TMs should be read in the sequence shown.

ACKNOWLEDGEMENTS

The Study Team acknowledges, with sincere appreciation, the contribution of many individuals and agencies consulted in the course of Phase 2 of the CSO Management Study. The Study Team especially acknowledges the assistance of the City of Winnipeg Project Management Committee and the Advisory Committee.

Contributors to the TMs included:

Consultants: Wardrop Engineering Inc./Tetr*ES* Consultants Inc.
in Association with Gore & Storrie Limited/EMA Services Inc.

G. Rempel, Project Manger
R.J. Gladding, Assistant Project Manager
R.R. Foster
D. Morgan
N. Szoke
G. Steiss
S. Quigley
R. Rempel
G. Mohr
D. Dagg
J. Anderson
P. Nicol
M. Parente
W. Clarke
R.G. Skrentner
D. Weatherbe
G. Zukovs
S. Black
L. Thompson
C. Rowney

City of Winnipeg: Water & Waste Department Project Management Committee

E.J. Sharp, Project Manager
D. Wardrop
M. A. Shkolny
A. Permut
W.J. Borlase
P. Lagasse
P. Kowalyk
T.R. Pearson
D. McNeil

TABLE OF CONTENTS

POTENTIAL CSO MANAGEMENT STRATEGIES

LIST OF ILLUSTRATIONS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

The purpose of the Phase 2 screening of Combined Sewer Overflow (CSO) control options is to identify the most appropriate technologies needed to achieve the study objectives, as they pertain to the establishment of a cost-effective, prioritized implementation plan for remedial work based on an assessment of costs and benefits of practicable alternatives. Once selected, these conceptual alternatives will be addressed in more detail, to expand on their specific attributes, either as region-wide technologies or in combination with other technologies, and to optimize their use in the long-term CSO control plan.

The main components of the Phase 2 screening process are:

- Definition of water quality issues/objectives
  - In this particular case, the water quality objectives for WWF have not been defined, therefore, the screening process must test the sensitivity/responsiveness of the CSO control options to respond to the water quality issues under a range of possible numerical evaluation criteria.

- Definition of available technology
  - The available CSO control technology range from "No Action", i.e., present conditions, to structurally intensive solutions such as full capture of CSO under all rainfall conditions, separation of the existing combined sewers, etc.

- Evaluation of the technologies for the Winnipeg situation
  - Defining the best CSO control options should be done on the basis of the relationship between cost and water quality benefits (Water Environment Federation (WEF), MOP, FD-17, 1989), which can include consideration of effectiveness in reducing CSO pollutant loadings, effects on beneficial uses, ability to be implemented, costs and other relevant factors. Cost-effectiveness is a major criterion according to the Terms of Reference for this CSO study. It is also compatible with the WEF policy and is consistent with the EPA CSO Control Policy.

This Technical Memorandum (TM) draws on the technical information presented in the preceding TMs and synthesizes this information to allow overall evaluation of the relative ability of different CSO control technologies to address the important water quality issues.

For purposes of review, the main water quality issues are briefly outlined, the existing conditions are evaluated relative to these issues, and potential CSO control options are evaluated for the Winnipeg circumstances.

In order to assess the various alternatives for screening purposes, a representative hydrologic year (1992) was selected on the basis of rainfall record and river flow records (see TM #3). It is recognized that other years may be significantly different (either wetter or dryer) from the representative year. Later in the study, when the range of control options has been refined, a broader range of rainfall and river flows, i.e., a 5 or 10 year record, will be used to assess the short list of control alternatives.

2.0 WATER QUALITY ISSUES

Water quality issues relating to CSOs were reviewed in Phase 1 with due consideration for the Manitoba Surface Water Quality Objectives (MSWQO) and the manner in which the Clean Environment Commission (CEC) considered that these discharges should be studied. This review of water quality issues was repeated in Phase 2, and confirmed that the discharge of CSOs in Winnipeg are particularly relevant to surface water quality for the following issues:

- **Aesthetics** - the river should be free from constituents attributable to sewage (e.g., floatables, scum, grease). The numerous outfalls in Winnipeg (CSO, LDS and sanitary sewage) represent a pollution control issue in this regard.
- **Microbiological Quality** - the microbiological quality of the Red and Assiniboine Rivers, as measured by the indicator organism, fecal coliforms, exceeds the MSWQO, chiefly because of discharges from the City's water pollution control centres (WPCCs) during dry weather conditions and CSOs during wet weather conditions. The river use of most

relevance to compliance with coliform density objectives is water-based recreation. The CEC has recommended that, in the Winnipeg area, the Red River be protected for primary and secondary recreation and the Assiniboine River, for secondary recreation for dry weather conditions. This implies fecal coliform objectives of 200 and 1,000 fc/100 ml for primary and secondary recreation, respectively. The CEC recommended additional study on the wet weather objectives.

In accordance with the foregoing, water quality issues associated with CSOs in Winnipeg relate mainly to aesthetic considerations and microbiological quality. The main focus of the screening of CSO control options in this TM relates primarily to these water quality issues of compliance with surface water quality objectives as well as the related issues of public perceptions and responsible environmental management.

3.0 EXISTING CONDITIONS

Before considering potential methods of improving the existing conditions, it is essential to describe these conditions, particularly the existing water quality regime in the local rivers, and the way in which the various sources contribute to, or individually affect, these water quality conditions.

The preceding TMs, particularly TM #1 Runoff and TM #3 Control Alternatives, have provided extensive analysis of the different loadings to the local rivers, with special attention to WWF loadings. TM #4, Receiving Stream, assessed the implications of these individual and collective loadings on the river water quality. This section summarizes the existing conditions, especially with respect to CSO loadings and their effect on the major water quality issues.

3.1 NUMBER AND VOLUME OF CSO DISCHARGES

The analysis of CSO shows that, for the representative year (1992), approximately 7 million m^3 of runoff is carried by the CS system during the recreation season (May 1 to September

30). This urban runoff is mixed with domestic and commercial/industrial wastewater and a major portion of this combined sewage overflows into the rivers. Table 3-1 shows that about 4 million m^3 of combined sewage overflows to the rivers (i.e., about 60 percent of the wastewater in the combined sewers overflows). The combined sewer system is intended to intercept about 2.75 x DWF during rainfall events. On average, the system more than achieves this intent, although the interception rates for individual districts vary widely across the 42 CS districts (see Table 3-2). The interception of approximately 4 x DWF means that a major portion of the flow in the combined sewers during rainfall, including sewage, is spilled to the rivers. On an annual basis, the amount of sewage lost to the river during these events is relatively small, i.e., about 1-2% of the annual sewage generated is lost during WWF events.

TABLE 3-1

COMBINED SEWER DISTRICTS
REPRESENTATIVE YEAR (1992) - MAY 1 TO SEPTEMBER 30

	Volume of Runoff (m^3)	Volume of Combined Sewage Overflows	Number of Overflows (Average of Districts)
Existing Conditions	7,000,000	4,000,000 m^3	18
		(59% of Runoff)	

3.2 RELATIVE LOADINGS TO THE RIVERS

The relative loading of CSO to the river, compared to other discharges, both DWF and WWF, are shown in Figure 3-1. These results indicate that volumes for WPCC and LDS discharges tend to dominate recreational, open water, and especially annual total volumes discharged to the Rivers. Although CSOs are still significant volumes (about 6% annually), the SSOs and interceptor overflow volumes are insignificant in comparison.

TABLE 3-2

Existing Control Summary

(Representative Year-1992)

District Number	District Name	DWF m^3/s	Interception m^3/s	X DWF	OverFlows	AREA Hectares	Volume of Overflow m^3
1	Alexander	0.035	0.155	4.4	21	160	111,000
2	Armstrong	0.02	0.524	26.2	7	146	7,000
3	Ash	0.082	0.301	3.7	22	735	504,000
4	Assiniboine	0.084	0.425	5.1	16	88	48,000
5	Aubrey	0.071	0.214	3.0	17	442	127,000
6	Baltimore	0.028	0.201	7.2	17	247	74,000
7	Bannatyne	0.153	0.613	4.0	9	263	31,000
8	Boyle	0.014	0.03	2.1	22	27	24,000
9	Clifton	0.077	0.236	3.1	19	494	204,000
10a	Cockburn	0.033	0.075	2.3	22	347	126,000
10b	Calrossie	0.001	0.028	28.0	12	10	5,000
11	Colony	0.134	0.425	3.2	16	230	72,000
12	Cornish	0.035	0.107	3.1	15	143	22,000
13	Despins	0.032	0.132	4.1	16	118	47,000
14	Doncaster	0.025	0.075	3.0	18	155	36,000
15	Douglas Park	0.001	0.095	95.0	9	25	3,000
16	Dumoulin	0.013	0.136	10.5	13	83	19,000
17	Ferry Road	0.059	0.126	2.1	22	292	141,000
18	Hart	0.039	0.101	2.6	23	227	114,000
19	Hawthorne	0.036	0.113	3.1	21	260	120,000
20a	Jefferson E	0.143	0.569	4.0	16	1003	184,000
20b	Jefferson W			Added to Jefferson East			
21	Jessie	0.066	0.176	2.7	22	399	230,000
22	La Verendrye	0.009	0.015	1.7	30	72	52,000
23	Linden	0.017	0.06	3.5	22	159	94,000
24	Mager Drive	0.091	0.309	3.4	22	781	156,000
25	Marion	0.032	0.22	6.9	17	231	94,000
26	Metcalfe	0.005	0.044	8.8	16	35	19,000
27	Mission	0.144	0.518	3.6	13	753	78,000
28	Moorgate	0.023	0.085	3.7	17	158	46,000
29	Munroe	0.077	0.237	3.1	21	590	247,000
30	Newton	0.01	0.166	16.6	10	82	14,000
31	Parkside			Modelled with Riverbend			
32	Polson	0.032	0.356	11.1	16	262	79,000
33	River	0.07	0.094	1.3	28	126	87,000
34	Riverbend	0.053	0.107	2.0	24	207	136,000
35	Roland	0.026	0.324	12.5	16	208	96,000
36	Selkirk	0.067	0.453	6.8	9	326	31,000
37	St. Johns	0.084	0.173	2.1	24	355	261,000
38	Strathmillan	0.003	0.062	20.7	9	85	6,000
39	Syndicate	0.01	0.069	6.9	19	76	44,000
40	Tuxedo	0.004	0.036	9.0	19	53	30,000
41	Tylehurst	0.05	0.176	3.5	20	216	129,000
42	Woodhaven	0.00227	0.027	11.9	20	66	27,000
	Minimum	**0.001**	**0.02**	**0.00**	**7**	**10,700**	**4,000,000**
	Maximum	**0.153**	**0.613**	**95**	**30**		
	Weighted Average			**4.2**	**17.8**		

Note: Assiniboine Park excluded from this summary

PH2REP.WK4

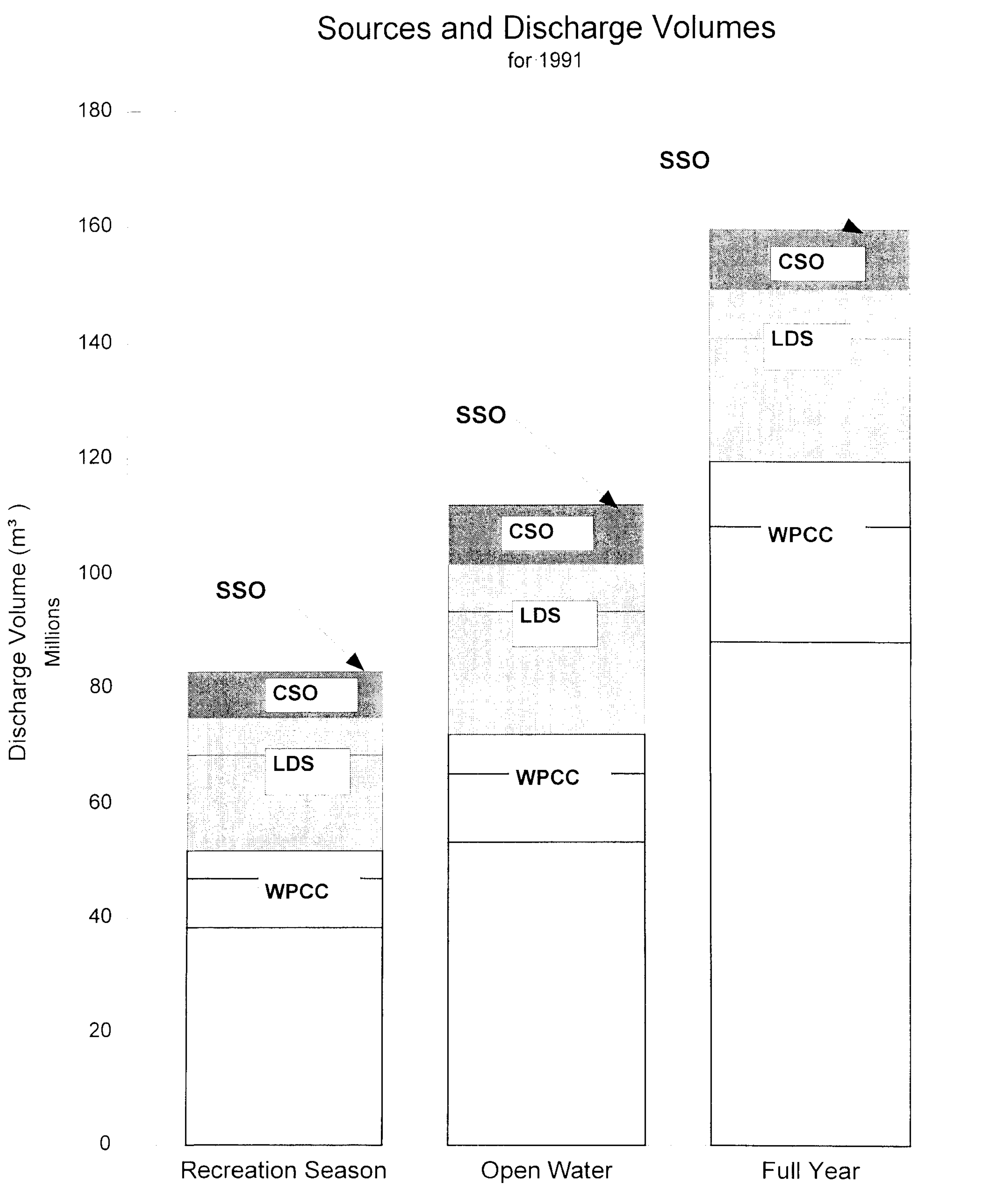


Figure 3-1

PERSPEC.WK4

By applying the EMC for fecal coliforms for each type of discharge, the perspective on the relative loadings changes. Relative loadings of fecal coliforms are shown in Figure 3-2. In this Figure, it is obvious that CSOs, along with plant discharges, tend to dominate loadings of fecal coliforms to the Rivers. LDS loadings are relatively small. SSO fecal coliform loadings, although these occur only during intense rainfall, are significant at 4 to 8% of the total. It must be noted that fecal coliforms are not conservative and tend to die-off relatively quickly, therefore the location and time of the overflow influences the relative impact of each discharge. These spatial and temporal impacts of coliform loading are assessed in TM #4 - Receiving Stream by a dynamic water quality model (US EPA's WASP).

3.3 COLIFORM DENSITIES IN THE RIVER

In the selected representative year, the average duration of compliance with the MSWQO at the 14 monitoring stations was estimated to be about 52% of the time for primary recreation (200 fc/100 mL) and 87% of the time for secondary recreation (1000 fc/100 mL). At the station with the lowest compliance (or the highest coliform densities), the compliance was 0% for primary recreation and 37% for secondary recreation. The above results reflect the improved effluent quality from the WPCCs in recent years; the compliance results were lower in years prior to this.

It is evident from the loading statistics that, during DWF, the WPCC effluent discharges are the main reason for high coliform levels in the rivers often resulting in densities above the MSWQO for both primary and secondary recreation. During WWF, the CSO loadings dominate the coliform loadings to the stream. The CEC has not yet recommended coliform objectives for WWF. If the same objectives for DWF were to apply for WWF, it is clear that CSOs would be mainly responsible for the general non-compliance with objectives during WWF.

CSO contributions greatly exceed those of the LDS. These elevated coliform levels in the rivers, caused by WWF, typically die-off to background levels in about 3 days, depending on river temperature, sunlight and many other parameters. The CSO events occur about 18 times between May 1 and September 30, i.e., a little less than once per week on average, and thus represent a significant factor in typical river water quality.

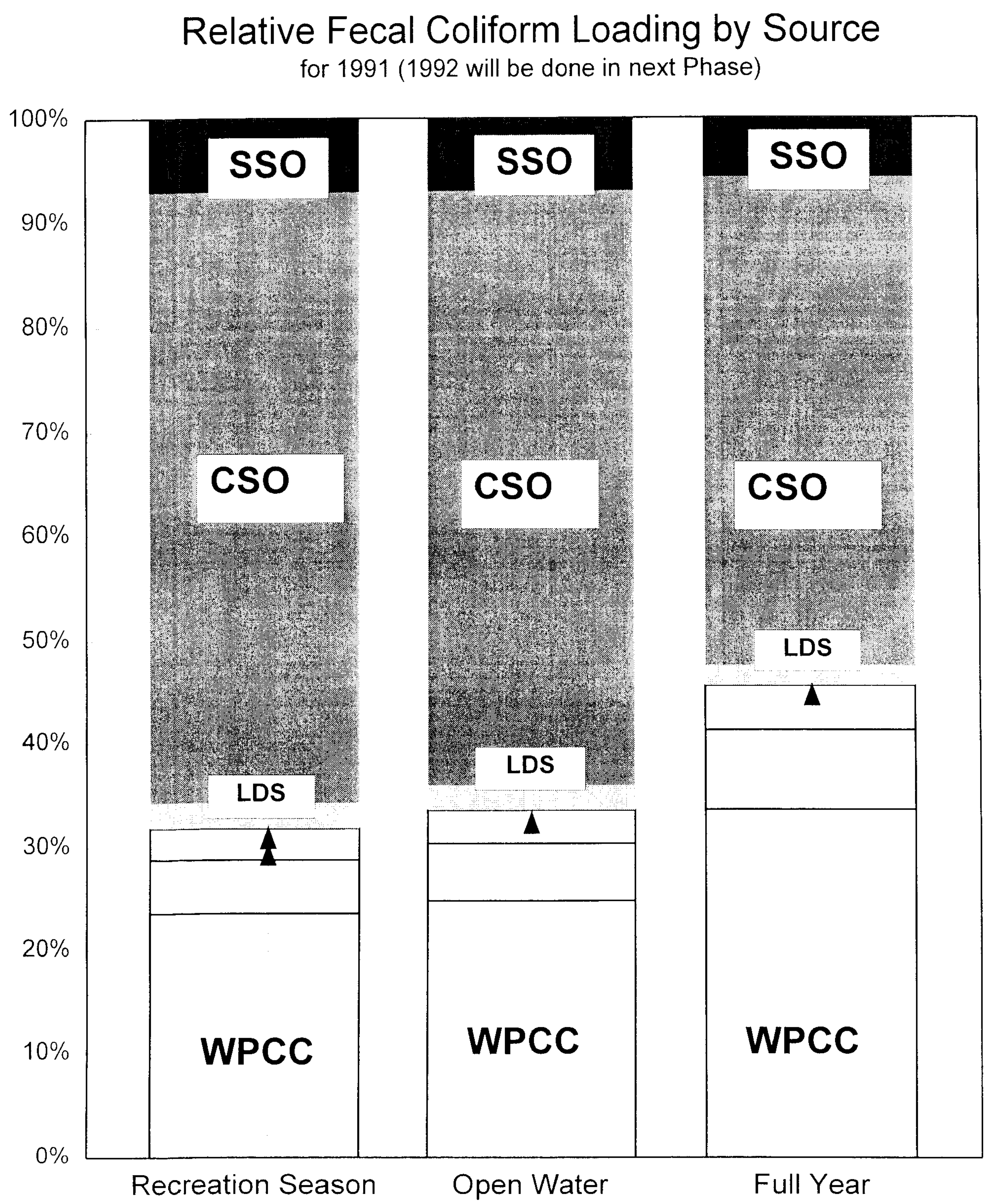


Figure 2-2

Source: TM#2-6 Figure 3-2.

3.4 HEALTH RISK

The average coliform conditions can be translated to an approximate measure of the health risk associated with recreational use of the rivers, specifically river use that could include immersion. These average conditions correspond to about 13 cases of gastrointestinal (GI) cases for 1000 immersions. This compares to about 10 GI cases/1000 immersions at the provincial objective for primary recreation (200 fc/100 ml). Thus, swimming or water-skiing in the Red River, under existing conditions, will typically incur an incremental level of risk of contracting GI compared to water quality at provincial objectives. During dry weather conditions, this increment of health risk is due mainly to the discharges of effluents from the WPCCs but, during and immediately after WWF, wet weather conditions, the increment of health risk is due mainly to CSOs.

3.5 AESTHETICS

CSOs present an issue with regard to aesthetics and public perception of river water quality. The MSWQO has statements that essentially require that surface waters should be free of constituents attributable to sewage or other human-induced discharges. During dry weather, the City of Winnipeg discharges to the Red and Assiniboine Rivers are not major factors in the conformance of the water quality in the Rivers to the general requirements. During wet weather, however, the storm sewers and combined sewer overflows discharge floating debris, oil, grease, litter and scum attributable to sewage. The frequency of overflows from combined sewers and land drainage also translates into a measure of the number of times material attributable to sewage is discharged directly into the river thereby causing aesthetic deterioration of the river quality. CSO are the main source of sewage-related constituents in the wet weather discharges to the Rivers.

The following sections describe the effects of different control technologies on these existing water quality conditions. The discussion begins with options that address DWF conditions and progresses to different CSO control options.

4.0 POTENTIAL CONTROL OPTIONS

The broad range of potential control options were reviewed in TM #3. Three main categories of options were identified:

1. Addressing the Dry Weather Flow (DWF) issues.

2. Optimizing the existing infrastructure for Wet Weather Flow (WWF).

3. Structurally intensive CSO control options.

Each is summarized briefly below. For more detail, the reader is referred to TM #3.

4.1 ADDRESSING THE DWF ISSUES

Two main activities relate to DWF water quality issues, dry weather overflows (DWO) and water pollution control centre (WPCC) disinfection.

4.1.1 Dry Weather Overflows

The overflow of sewage during dry weather is contrary to good environmental practise. The City of Winnipeg has made substantial and continuous efforts to avoid DWOs, but there appears to be several cases where DWOs from combined sewer districts do occur. This is typical experience when a CSO study is done, i.e., DWOs are found to occur even with responsible operation of the existing infrastructure. These are currently being investigated by the City. These DWOs appear to have had significant impact on coliform levels in the rivers. In Winnipeg there are a number of CS districts (Tylehurst, Assiniboine, Cockburn) that require follow-up action with other districts on the Assiniboine River being suspect. The remedial action may involve modifications to the interception facilities, pumping station upgrades, etc.

These actions, as shown later, are of immediate priority. Conceptually, the costs for upgrades are estimated to be less than $2 Million.

4.1.2 WPCC Disinfection

The disinfection of the treated effluents from the three WPCC's has been reviewed previously. Chlorination-dechlorination is proven technology, although there are major environmental (socio-economic, biophysical) issues associated with the use of chlorine. Chlorination is typically less costly than other disinfection techniques. UV technology, which has less environmental concerns, has been tested on local wastewaters and found to be cost-effective for the SEWPCC and WEWPCC. Evolving UV technology may make this technology competitive for the NEWPCC. The approximate costs are (Wardrop June 1992):

NEWPCC = $21 Million*
SEWPCC = $7 Million*
WEWPCC = $5 Million*

*Estimates include 20% estimating Contingency and 20% allowance for Engineering, Finance and Administration.

4.2 OPTIMIZING EXISTING SYSTEM

The first step in an incremental program for implementing CSO controls is to optimize the existing system. As discussed in TM #3, in Winnipeg, this would comprise the utilization of inline storage, through basic real time control, and using the full conveyance capacity of the Main Interceptor (approximately 5 x current DWF).

4.2.1 5 x DWF

It was determined (TM #2) that the Main Interceptor could be operated so as to convey 5 x current DWF, an increase from the nominal 2.75 x DWF for which it was designed. The estimated capital cost of the associated increase in pumping capacity (pumped districts) and upgrading flow regulators (gravity districts) was $15 million.

4.2.2 Inline Storage

The most cost effective means of diverting WWF for treatment at the WPCC, and hence reducing volume and frequency of CSOs, is to take advantage of the available inline storage in the City's CS trunks and storm relief sewers. This would be done in a fashion which will not compromise basement flood protection. The estimated capital cost is $20 million. This option was assessed in conjunction with increasing Interceptor Capacity to 5 x DWF. In Phase 3 it can be assessed in conjunction with the existing average interception rate (4 x DWF).

4.3 STRUCTURALLY INTENSIVE OPTIONS

In the case that the above measures still do not meet objectives or provide adequate overall public satisfaction, structurally intensive options would be installed. These could be either system wide, or district-specific technologies and could involve a combination of a number of different options in different CS districts. The various options considered were: central treatment; tunnel and offline storage; Vortex Solids Separators with Disinfection; Retention Treatment Basins with Disinfection and Separation. Floatables removal was also reviewed as separate possibility.

4.3.1 Central Treatment

Intercepting full CSOs and conveying these large peaks to a central treatment facility is considered simply impractical. Conveyance of flows for treatment at the NEWPCC, up to the maximum delivery capacity of the Main Interceptor, is a practicable alternative. This could require expansion of the NEWPCC primary plant at an estimated capital cost of $25 million.

4.3.2 Tunnel Storage

Relatively deep tunnels can be used for storage and/or conveyance of combined sewage to the NEWPCC.

This system could be designed to store 100% of the runoff from the highest rainfall (1,000,000 m^3 of storage) or it could be sized to reduce the number or volume of overflows to approach the EPA Presumptive limit (4 overflows or 85% storage). The latter would require an estimated 300,000 m^3 for the representative (1992) year. The estimated capital costs of these two approaches is $650 million (1,000,000 m^3) and $400 million (300,000 m^3).

4.3.3 Offline Storage

Near surface, distributed storage with tanks located near the outlet of the combined sewer trunks, could be a cost effective alternative to tunnel storage. The benefits would be the same, with conveyance being provided by the Main Interceptor. The estimated capital cost of a storage system equivalent to the smaller tunnel option (300,000 m^3) is $210 million.

4.3.4 Vortex Solids Separators (VSS)/Disinfection

VSSs comprise a high rate, solids removal device, designed to render the wastewater suitable for disinfection. These units would be located at the CS outlet, near the diversion structure. The underflow from these units, which contain the removed solids, would be discharged to the Interceptor during dry weather. For the Phase 2 exercise the units were sized on the basis of utilizing UV disinfection. The estimated capital cost of CS installing VSS/disinfection units on a CS system-wide basis is $440 million.

4.3.5 Retention Treatment Basins (RTB)/Disinfection

RTBs are effectively segmented storage basins, located at the CS outlet. In addition to storage, the units are designed to act as high rate sedimentation basins for an additional increment of flows. The purpose of the device is to provide disinfection for the flow-through increment, thereby providing fecal coliform removal for a greater flow than the equivalent storage basin. The stored component is diverted to the Interceptor in dry weather. The estimated capital cost of installing RTB/Disinfection units on a CS system-wide basins is $300 million. For the 1992 year this would mean no untreated overflows.

4.3.6 Sewer Separation

CSOs can be eliminated by the construction of a separate collector system for sanitary sewage. The benefits comprise significant reductions in the discharge into the rivers of fecal coliforms and solids attributable to sanitary wastes. The estimated capital costs are $1,000 million.

4.3.7 Floatables Removal

The above options address both the fecal coliform issue and floatables control. There are devices available which would address the issue of floatables removal in isolation from fecal coliforms. Two such technologies were considered, both of which would be located at or near the CS outlet. Mechanically cleaned bar screens could be installed in housed facilities at the end of each CS trunk, at an estimated capital cost of $110 million.Trash nets (e.g., Fresh Creek "TrashTraps") could be installed in the rivers on the end of each trunk, at an estimated capital cost of $30 million.

4.4 POTENTIAL COMBINATION OF TECHNOLOGIES

Table 4-1 provides a list of potential combinations of Control Options. Item 1 comprises the disinfection of WPCC effluent and DWO corrections. It is the basic building block for any CSO Management Plan. It has limited impact on WWF conditions but has a dramatic impact on overall river conditions, especially as it relates to fecal coliform. Items 2 and 3 comprise optimization of the existing systems, i.e., increasing the Main Interceptor to its potential capacity and taking advantage of available inline storage in the major trunks and relief sewers. Intercepting 5 x DWF would not, in itself, have a major impact on CSOs, however, it will improve the emptying of storage (inline or offline) for conveyance to the NEWPCC. Items 1 and 2 together would be the first and most effective step in WWF control.

All other options, except for full CSO separation and regional tunnel storage, are supplemental to the combination of 1 and 3 since the latter comprise the most cost-effective means of reducing CSO volumes and frequency and therefore reduce the required capacities of the storage and disinfection options (4a, 4c and 5). They would also form the basic program for the Floatables Removal option.

In the case of full separation, and regional tunnel storage, option 1 would still be basic, but option 3 would only be implemented to obtain an early improvement in wet weather conditions in the Rivers.

5.0 EVALUATION OF OPTIONS

The evaluation of alternatives, in order to select the options for more detailed evaluation in Phase 3, will be done with an emphasis on cost-benefit relationships, where benefits will be

TABLE 4-1

POTENTIAL COMBINATIONS OF CSO TECHNOLOGIES

CONCEPTUAL OPTIONS		ROLE
1)	Disinfect WPCC effluent and DWO corrections	Common to all
2)	Intercept 5 X DWF	Supplemental to 1
3)	In-line storage and 5 x DWF	With 1 comprises first stage of WWF control
4a)	Distributed Storage (300,000 m^3)	Supplemental to 1 & 3
4b)	Tunnel Storage (300,000 m^3)	Supplemental to 1 & 3
4c)	Regional Tunnel Storage (1,000,000 m^3) - Eliminate CSO	Supplemental to 1
5)	Full CSO disinfection (this could be partial)	Supplemental to 1 & 3
6)	Full CSO separation	Supplemental to 1
7)	Floatables Removal	Supplemental to 1 & 3

For all combinations, the correction of DWOs and the disinfection of WPCC effluents is common. For most logical combinations, the optimization of existing infrastructure is also a common component. Other factors, such as cost, enter into this evaluation, as discussed in Section 5.

related to estimated water quality improvements associated with the different control methods. The water quality improvements will use the following measures:

- Compliance with Water Quality Objectives
  - The provincial water quality objectives for fecal coliforms currently considered as applicable (under dry weather conditions) will be used as a measure of compliance for the different control options.

- Public health risk
  - The health risk (GI) associated with the use of rivers for recreational purposes, as estimated from recognized epidemiological risk equations, will be estimated for different controls.

- Volume and number of CSOs
  - This parameter is considered a surrogate for aesthetics (discharge of floatables is considered to relate approximately to CSO volume) and other related concerns, such as the overflow of raw sewage (which is a policy and public perception issue) and other water quality parameters associated with urban runoff (such as sediments, metals, etc.).

Other relevant parameters such as practicality of implementation, land use, environmental issues, etc., will also be used in the evaluations.

5.1 COMPLIANCE WITH WATER QUALITY OBJECTIVES

Table 5-1 shows the average compliance with both primary and secondary recreation coliform objectives (200 and 1,000 fc/100 m) for the 14 monitoring stations on the Red and Assiniboine Rivers. Compliance with the primary recreation objectives would bring corresponding compliance with irrigation objectives, if these are considered applicable. The monitoring stations are typically located at the various bridges on the rivers and the average of these locations is thus representative of water quality in the urban reaches. The assumption implicit in the averaging of these data is that river users are equally likely to swim

Table 5-1
Compliance Under Different Control Scenarios

Option - Description	Primary Recreation Objective (200 FC/100mL) Average[1] Compliance	Primary Recreation Objective (200 FC/100mL) Minimum[2] Compliance	Secondary Recreation Objective (1,000 FC/100mL) Average[1] Compliance	Secondary Recreation Objective (1,000 FC/100mL) Minimum[2] Compliance	CAPITAL COST Option Millions	CAPITAL COST Cumulative Millions
Calibrated 1992	52.1%	0.0%	86.7%	37.0%	$0	$0
Dry Weather Flows						
1a - DWO Correction					$2	$2
1b - WPCC Disinfection	89.2%	74.6%	92.8%	82.0%	$33	$35
Wet Weather Flows						
2) System Optimization						
a - 5xDWF	89.7%	76.3%	93.3%	83.4%	$40	$75
b - 5xDWF+Inline Storage	91.6%	79.8%	94.7%	86.7%	$20	$95
3) Storage						
a - Distributed Storage					$210	$305
b - Tunnel Storage					$400	$495
c - Major Tunnel Storage	95.5%	86.9%	98.8%	93.5%	$650	$745
4) Disinfection						
a - RTB/Disinfection[1]	95.5%	86.9%	98.8%	93.5%	$300	$395
b - VSS/Disinfection	95.5%	86.9%	98.8%	93.5%	$440	$535
5) Separation						
a - Complete Separation	94.7%	84.4%	98.3%	92.2%	$1,000	$1,035

Notes
1 Average Compliance is the average compliance for all 14 monitoring stations throughout the Study Area reaches

2 Minimum Compliance is the lowest compliance frequency of the 14 stations

or waterski at any location on the Rivers. The table also shows the minimum compliance of the 14 stations for the representative year. These compliance performances are shown for the various control technologies.

The results are also shown graphically in Figure 5-1 in "cost-benefit" relationship. The following observations apply.

Existing Conditions

- Compliance, as discussed earlier, under existing conditions occurs about 50% of the time, on average, with the primary recreation objective and about 87% of the time with the secondary recreation objective. Compliance for primary recreation is only occasionally achieved at the station just downstream of the NEWPCC. This lack of compliance has long been an issue between the City and the Province.

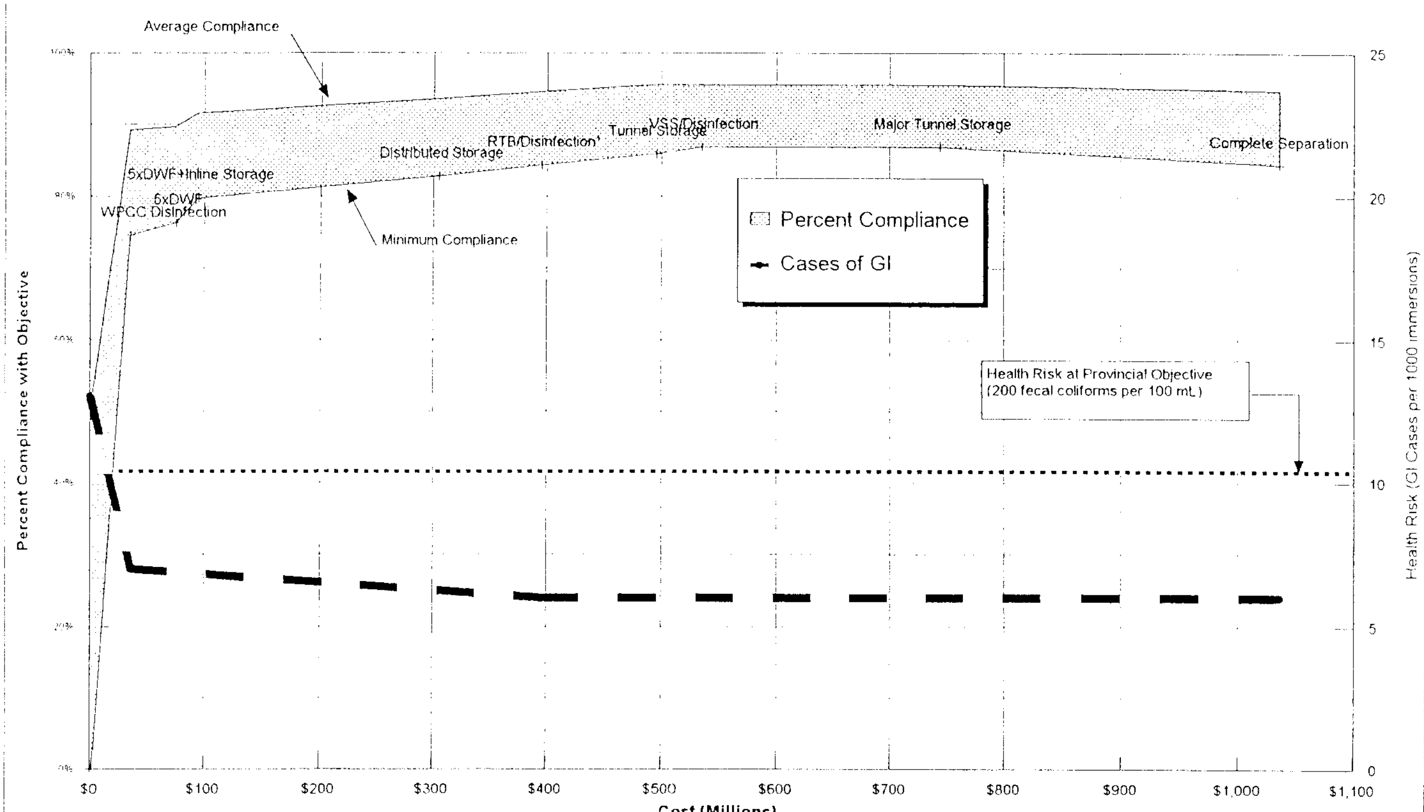
Dry Weather Flow

- Implementing disinfection at the WPCCs and correcting DWOs will result in very significant improvements in statistical compliance, with compliance averages of about 89% to 93% for primary and secondary recreation numerical objectives, respectively. The minimum compliance increases from virtually none of the time to 75% to 82% for primary and secondary recreation, respectively. This improved compliance has a capital cost of about $35 million, (WPCC disinfection and DWO corrections). These effects can be achieved with little community disruption, limited environmental concerns, and relatively low cost.

Optimizing Existing Infrastructure

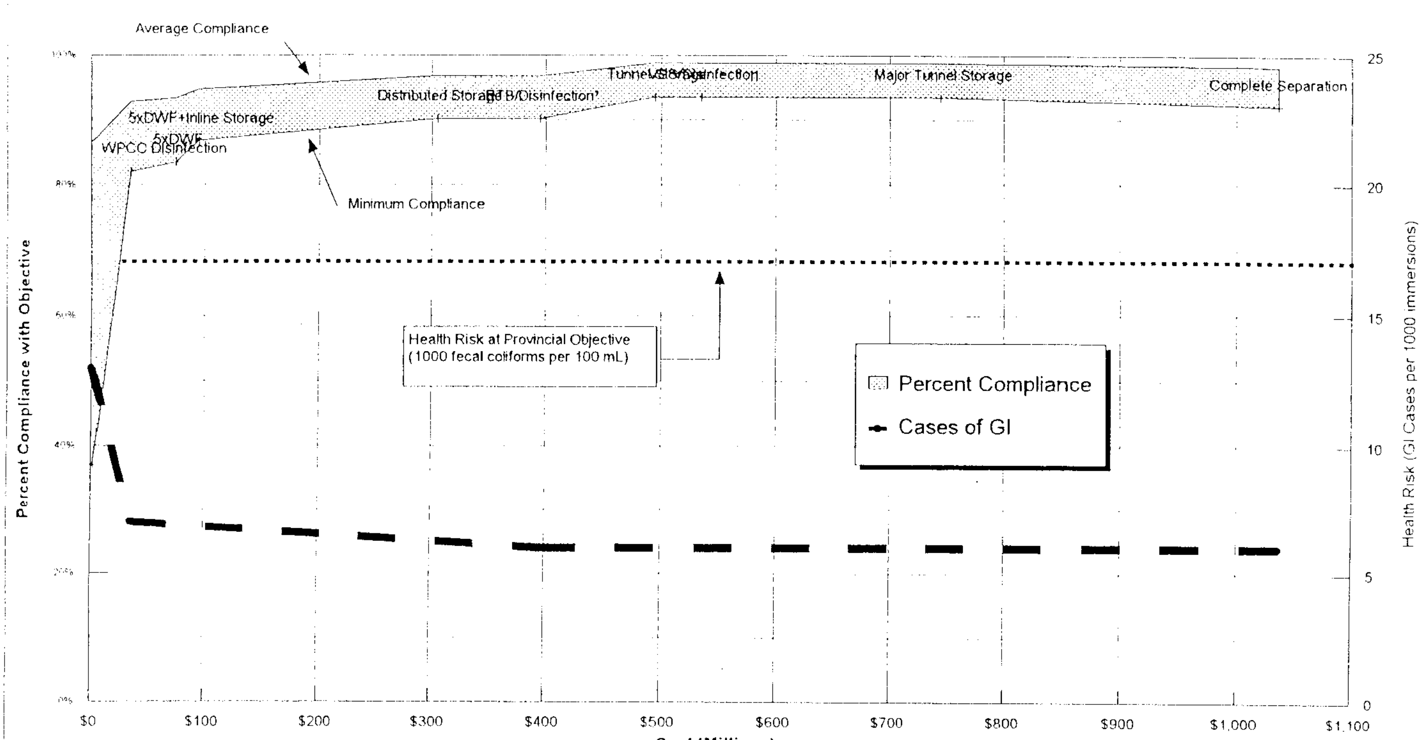
- Optimizing the existing system through increasing the interception rate provides only a very slight incremental benefit in terms of improved compliance with coliform objectives (average improvement of about 0.5% of the time) with a modestly larger increment of benefit (about 1.5 to 2% of the time) associated with increased interception combined with the use of in-line storage. These improvements are relatively easy to implement and

Compliance with 200 Fecal Coliforms per 100 mL Objective
for Different Control Scenarios



1. Average Compliance is the average compliance for all 14 monitoring stations throughout the Study Area reaches
2 Minimum Compliance is the lowest compliance frequency of the 14 stations

Compliance with 1000 Fecal Coliforms per 100 mL Objective
for Different Control Scenarios



Compliance With Manitoba Microbiological Objectives and Associated Health Risk

1. Average Compliance is the average compliance for all 14 monitoring stations throughout the Study Area reaches
2 Minimum Compliance is the lowest compliance frequency of the 14 stations

Figure 5-1

relatively low in cost ($95 million including disinfection and a possible increase of NEWPCC primary plant capacity).

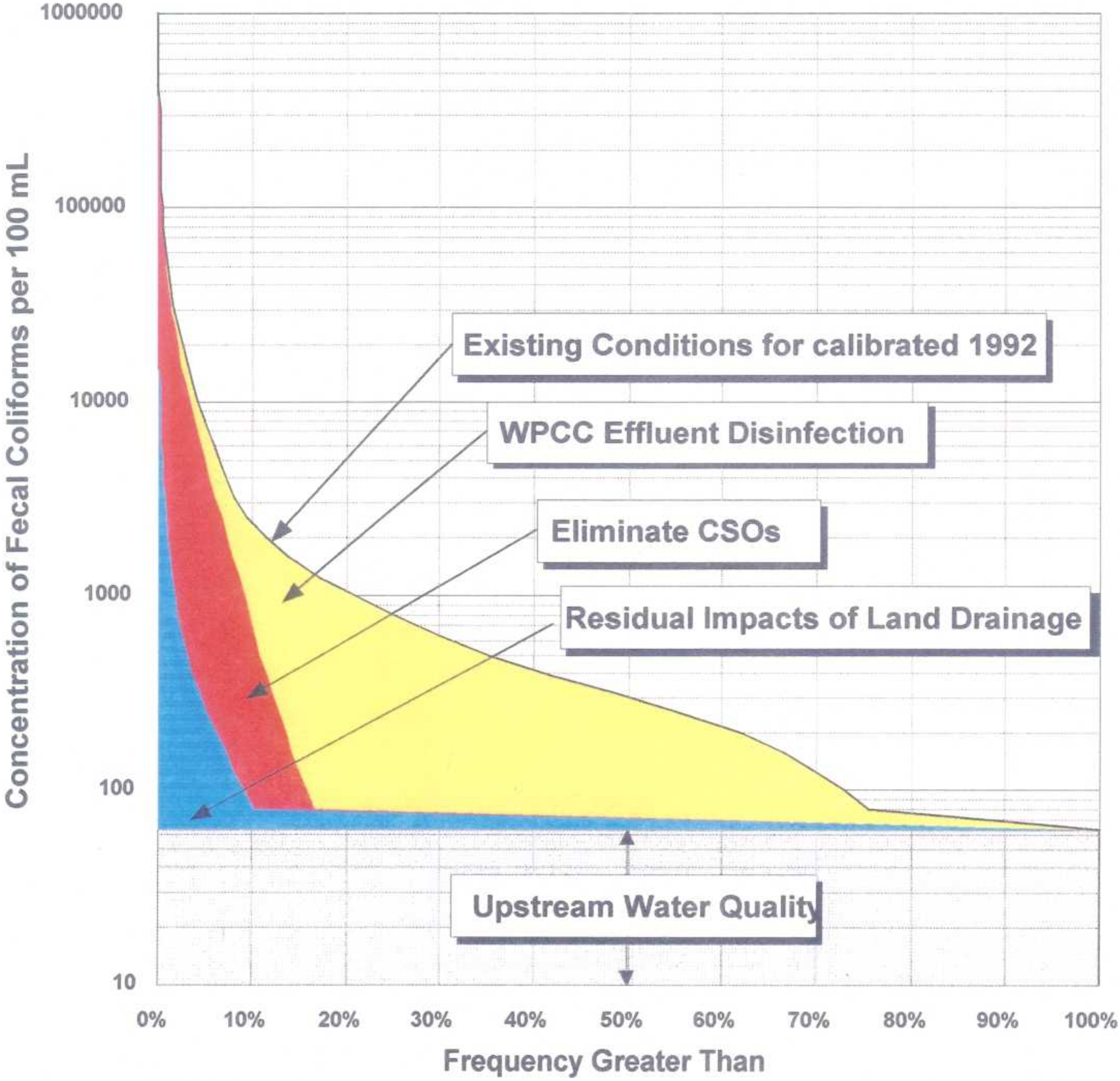
Structurally Intensive Options

- Storage of CSOs, either in the form of distributed storage tanks or tunnel storage (to capture about 85% of the volume of CSO runoff, the EPA "presumptive" target), or a massive regional storage tunnel sewer, would provide only very slight improvements in overall compliance (to about 95% and 98% of the time for primary and secondary recreation objectives, respectively) as shown in Figure 5-1. The cost/benefit ratio for these improvements is very high. The costs of these options could range from $300 to $750 million (including DWF and existing system upgrades).

- High rate treatment technologies, such as RTB and VSS would also provide slight improvements in compliance, in combination with increased interception and use of in-line storage, in the average 95% to 98% range of compliance. The range of costs is about $400 to $530 million but will depend on the "design event" for these devices and, in the event UV disinfection is applied, the degree of effectiveness of UV technology with CSO which is still not proven.

- Complete separation would also improve compliance to about 95% and 98% of the time (a very moderate increment), respectively, for primary and secondary recreation but the costs to achieve this improved compliance will be in the order of $1000 million. Separation does not achieve full compliance because the urban runoff, formerly carried in combined sewers, would now be discharged to the rivers as land drainage and still would cause excursions from compliance.

- The degree of compliance, and the modest benefits in terms of compliance achieved with the different control options is best illustrated on Figure 5-2. This figure shows the statistical frequency of specific coliform densities in the Rivers. These data include all hourly estimates of coliform densities at all segments modelled on the Rivers in 1992, from just upstream of Winnipeg to Lockport. The figure shows the percentage of time that a given coliform density is exceeded. These data show that, under existing



Note: All modelled segments, upstream of Winnipeg to Lockport, were used in this assessment

Accumulative Frequency of Modelled Fecal Coliforms Concentrations for Various Control Scenarios

Figure 5-2

conditions, the 200 and 1000 fc/100 mL objectives are exceeded frequently, however, once the WPCC effluents are disinfected, the exceedances are drastically reduced, i.e., the remaining exceedances relate only to the WWF events. These WWF events cause very high levels of coliform but do not persist for very long times. As a result, the added benefit in terms of compliance with objectives, is very limited with all CSO control options.

5.2 ESTIMATED HEALTH RISK

The intent of placing limits on coliform densities is to protect the health of users of the river using recognized epidemiological equations. The health risk associated with the use of the rivers for recreational purposes under existing conditions and for various control scenarios can be estimated. These health risks can also be translated into GI case loads based on estimates of current river uses. Figure 5-1 shows the health risk in terms of GI cases/1000 immersions for different scenarios. Some observations:

Existing Conditions

- The health risk under present conditions, on average, represents a symptom case rate of about 13 cases of GI per 1,000 immersions. Given the estimated use of the rivers for swimming, waterskiing, boating, etc. this represents a case load of about 74 GI cases/year from this use. The health risk implication in the MSWQO for coliform at the primary recreation objective (200 fc/100 mL) is about 10 cases/1000 immersions (57 GI cases/year). This is deemed to be the risk acceptable to society.

Dry Weather Flow

- WPCC effluent disinfection reduces the health risk, on average, to about 7 GI cases/1,000 immersions, which is somewhat less than the risk inherent in the provincial objective (10 cases/1,000 immersions). This translates to a reduction in annual cases of about 34 cases, assuming similar levels of river use would occur.

Optimizing Existing Infrastructure

- Optimizing existing infrastructure, through increased interception and/or in-line storage, does little to change the overall health risk.

Structurally Intensive Options

- Disinfection of all CSOs, or separation of the sewers, would reduce the estimated risk to about 6 cases/1,000 immersions, i.e., a very small increment for an associated cost of $400 to $1,000 million.

The reduced health risk associated with any of the DWF, and expressly the WWF control options, is very slight. The avoided GI cases are immeasurable in the context of the background of 300,000 to 700,000 GI cases per year in the community. The health risk associated with the use of river water for greenhouse or crop irrigation purposes, which is limited, is so small that it cannot be quantified. The matter of health risk is, nonetheless, a serious issue and the appropriate control will reflect public value judgements and environmental policy issues.

5.3 VOLUME AND NUMBER OF OVERFLOWS

Figure 5-3 shows the CSO volumes and number of overflows during the recreation season for different control technologies, including the cost of a range of alternative control options, in tabular form. Figure 5-3 also shows the volume and number of overflows plotted against the cost of the various control options.

Some observations:

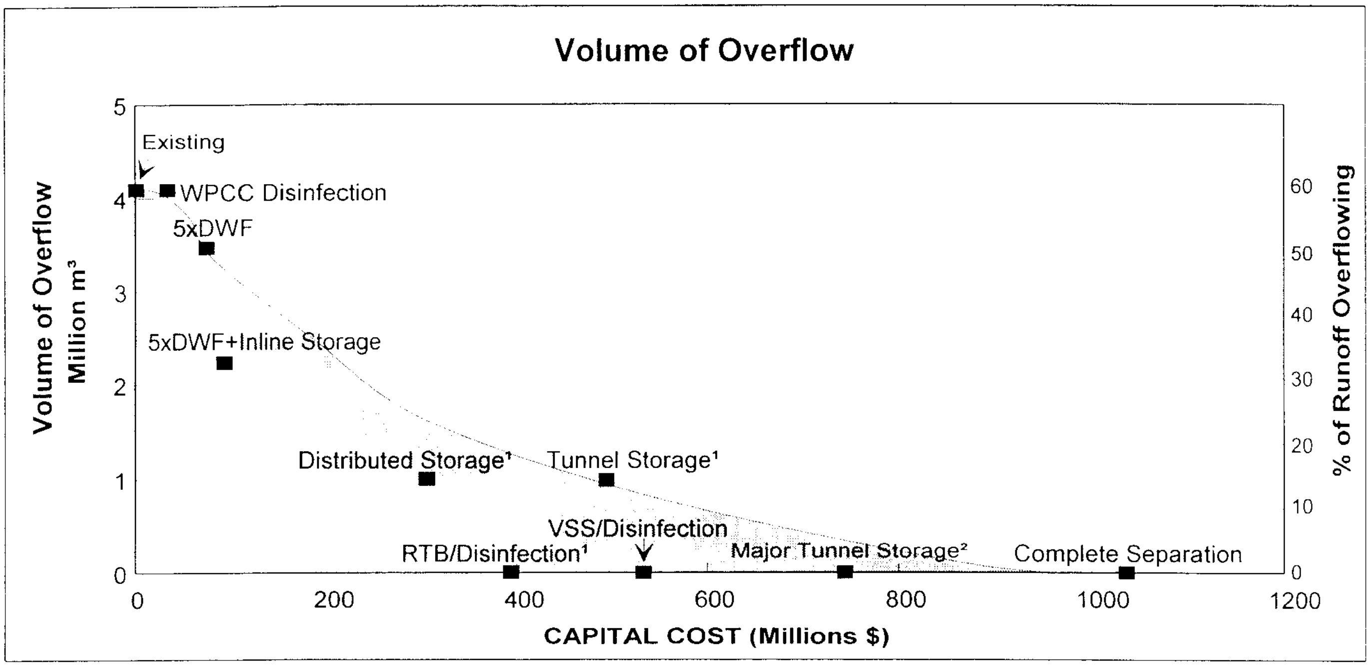
Existing Conditions

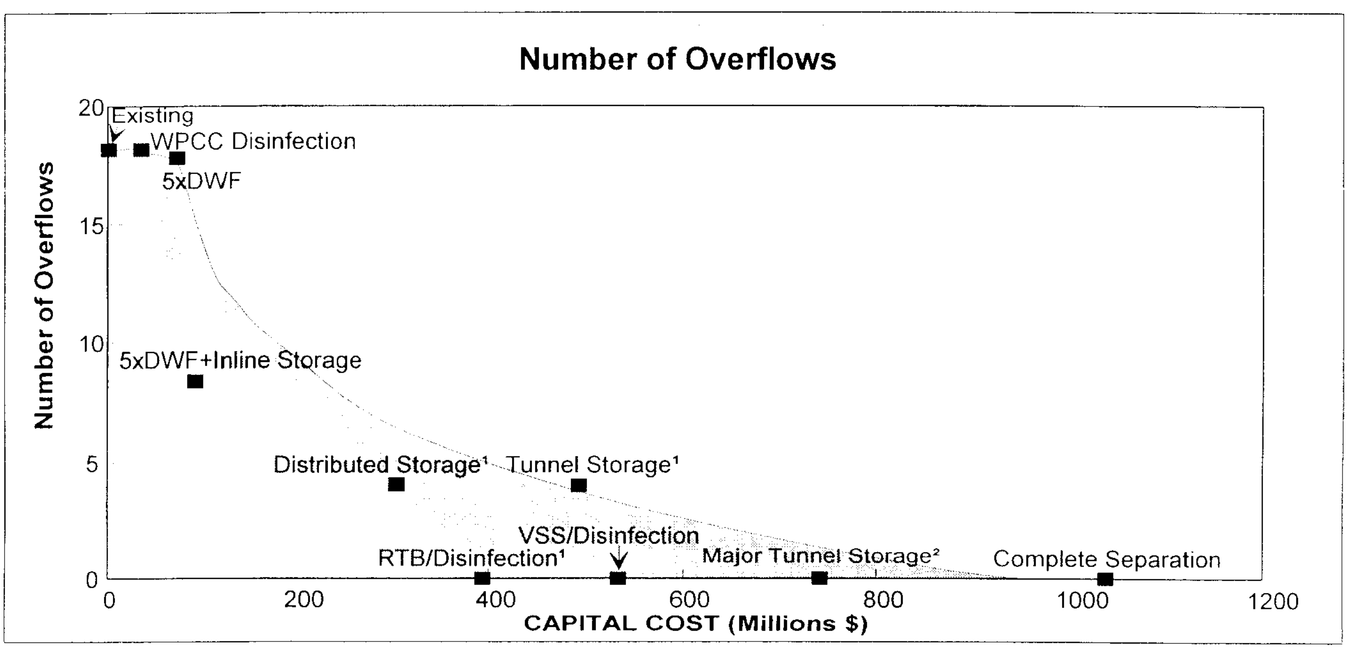
- Over the season, about 60% of the wet weather flow in combined sewers overflows to the river. The number of overflow events varies considerably from district to district,

CSOs UNDER DIFFERENT CONTROL SCENARIOS

Option		Description	Volume of Overflow: Million Cu. M.	Volume of Overflow: % of Runoff	Number of Overflows: Average of Districts	Number of Overflows: % of Existing	CAPITAL COST: Option Millions	CAPITAL COST: Cumulative Millions
		Runoff	6.96	100%				
		Existing	4.09	59%	18.2	100%	$0	$0
1a	DWF	DWO Correction	4.09	59%	18.2	100%	$2	$2
1b		WPCC Disinfection	4.09	59%	18.2	100%	$33	$35
2a	System	5xDWF	3.47	50%	17.8	98%	$40	$75
2b	Optimization	5xDWF+Inline Storage	2.25	32%	8.4	46%	$20	$95
3a	Storage	Distributed Storage[1]	1	15%	4	22%	$210	$305
3b		Tunnel Storage[1]	1	15%	4	22%	$400	$495
3c		Major Tunnel Storage[2]	0	0	0	0	$650	$745
4a	Disinfection	RTB/Disinfection[1]	0	0	0	0	$300	$395
4b		VSS/Disinfection	0	0	0	0	$440	$535
5	Separation	Complete Separation	0	0	0	0	$1,000	$1,035
6a	Floatable	Trash Netting	2.25	32%	8.4	46%	$30	$125
6b	Control	Screening	2.25	32%	8.4	46%	$110	$205

Note: 1 Assumes 300,000m^3 of Storage. Results are estimates Only
Assumes 1,000,000m^3 of Storage. Results are estimates Only





numb-vol
01_files

Figure 5-3

however, on average about 18 overflow events occur during this season from the 42 combined sewer districts.

Dry Weather Flow

- Implementing WPCC effluent disinfection and DWO correction, while achieving important dry weather improvements in water quality and, perhaps, in public perception, will not change the wet weather loadings, i.e., the CSOs and LDS discharges.

Optimizing Existing Infrastructure

- Increasing the interception rate to 5 x DWF (the maximum interceptor capacity), compared to the existing average interception of 4 x DWF, will achieve marginal improvements, i.e., about 1 less overflow per year and about 10% more runoff capture is achieved. This provides very modest benefit, although it is practical to do these upgrades.

- The use of in-line storage in the existing collection system combined with increased interception rates (5 x DWF) has significant benefits, about 68% capture of combined sewage (32% of runoff will overflow) and reduction in the number of CSOs from about 18 to 8 events per season. This would be achieved at relatively low cost ($95 million, including the cumulative cost of WPCC disinfection, DWO correction and WPCC upgrades for increased WWF).

Structurally Intensive Options

- Distributed storage tanks, at each district observing several districts, would reduce the number of overflows to about 4 per year or capture about 85% of the runoff. These performance levels equate to the CSO control objectives outlined in the EPA CSO Control Policy. These performances are achieved at a cost of about $300 Million, including the optimization of existing infrastructure, and would also incur considerable local disruption, environmental and land-use concerns. These same performance levels could be achieved with the use of tunnel sewers, at a cumulative cost of about $500 Million, but with less local land-use and environmental concern.

- Massive tunnel storage to capture all combined sewage runoff and thus eliminate all CSOs would have a cumulative cost of about $750 Million.

- High rate treatment technologies, such as RTB/VSS (including disinfection), would provide storage and at least partial disinfection of all CSOs, for all rainfalls, but still at relatively high costs (cumulative costs of $400 to $530 Million) and would raise many concerns regarding local land-use at the CSO outfalls, environmental issues, operating costs, etc.

- Complete separation would eliminate CSOs (or untreated CSOs) but is achieved at extremely high cost ($1,000 million).

From the standpoint of reducing the number and volume of CSOs, the use of inline storage and/or distributed storage (tank or tunnel sewers) appears to be cost-effective and worthy of additional study. If distributed storage was selected, area-wide real-time control could be effective in optimizing the use of system storage and thus further enhance the ability of the system to deal with rainfalls that are unevenly distributed across the City. If WPCC effluent disinfection is implemented, the volume and number of overflows of CSO control appears to be more useful than compliance or health risk.

5.4 AESTHETICS CONTROL

There are control options that are worthy of consideration in terms of specific roles in CSO control. Floatables capture, through trash nets or screens, would not improve compliance with coliform objectives or reduce the number or the volume of CSOs but can reduce the aesthetic impact of CSOs. Therefore, this option could be considered as a supplement to optimizing existing infrastructure, if aesthetic control was considered as a prime objective as opposed to coliform control.

5.5 OVERALL EVALUATION

Figure 5-1 and Figure 5-3 illustrate the characteristics of the various control options in terms of estimated region-wide capital costs and their water quality benefits. These figures illustrate the "trade-offs" in costs. To supplement these evaluations, Table 5-2 presents an evaluation of the control options in the context of a relative ranking of the options against performance attributes and several other important factors such as practicability of construction, environmental issues associated with implementing the option, operating effort, and land use considerations.

From this information, the following observations can be drawn:

Dry Weather Flow

- DWO corrections are the first priority action and should be addressed as soon as possible. This will not affect CSOs but will reduce coliform loadings and achieve significant benefit in improved compliance with environment policy and with coliform objectives under DWF conditions. This is a best-management practise that is applicable under any circumstances.

- WPCC effluent disinfection is a logical first step in any CSO control program that involves microbiological control, i.e., addressing the coliform water quality issue. It is relatively low in cost and provides significant benefit in improved compliance with coliform objectives (approximately 40% increment in compliance with the primary recreation objective), since these WPCC effluents are continuous in dry and wet weather. In fact, statistically, compliance may be achieved with this measure alone. This measure does not affect WWF discharges at all, including CSO frequency or volume. The reduced coliform levels provide a modest reduction in public health risk but probably would provide a significant benefit in improved public and regulatory perception.

Table 5-2
Evaluation Summary of Control Options

OPTION	Ability to Reduce No. of CSOs	Ability to Reduce Volume of CSOs	Ability to Improve Compliance (coliforms)	Ability to Reduce Health Risk	Relative Cost	Construction Practicability	Operating Effort	Land Use Issues	Environmental Issues
DWF Issues									
• WPCC disinfection & DWO correction	N/A	N/A	High	**Low**	Low	High	Moderate	N/A	Low
Optimizing Existing Infrastructure									
• BMP	**Low**	**Low**	**Low**	**Low**	Low	High	Low	Low	Low
• 5 x DWF	**Low**	**Low**	**Low**	**Low**	Low	High	Moderate	Low	Low
• 5 X DWF/in-line storage	Medium	Medium	Medium	**Low**	Low	High	Moderate	Low	Low
Structurally Intensive									
• Complete separation	High	High	High	**Low**	**Very High**	**Low**	Low	**Very High**	**High**
Storage									
• Tunnel (some overflows)	High	High	Medium	**Low**	**High**	**High**	Moderate	Short Term	Construction Only
• Tanks (some overflows)	High	High	Medium	**Low**	**High**	Medium	Moderate	Medium	Medium
• Tunnel (eliminate CSOs)	High	High	High	**Low**	**Very High**	**High**	Moderate	Short Term	Construction Only
High Rate Treatment with Disinfection									
• RTB	High	High	High	**Low**	**High**	Medium	**High**	**High**	**High**
• VSS	High	High	High	**Low**	**High**	Medium	**High**	**High**	**High**
• Central Treatment						**Impractical**			

- denotes: Negative ranking (black)
- denotes: Intermediate ranking (grey)
- denotes: Positive ranking (white)

Optimizing Existing Infrastructure

- Optimizing the use of existing infrastructure either through increased interception rates and/or in-line storage is relatively low in cost and provides significant reduction in the number and volume of CSOs. These measures are generally regarded as an appropriate priority action for any CSO control program. This would also likely translate into improved public perception and environmental stewardship. It does not increase the overall duration of compliance with coliform objectives very much. These measures do little to reduce floatables capture or aesthetic control.

Structurally Intensive Options

- The area-wide application of structurally intensive control measures such as separation or massive regional tunnel storage to capture all CSOs does not seem warranted. The costs associated with these measures increase very sharply (as shown in Figures 5-1 and 5-3), compared to other intermediate options, and they provide very small incremental benefits. As well, in the case of separation, they present very serious ancillary problems. Separation would be extremely disruptive to the residential and business community, so much so, that it may well be considered impractical, as has been found in many other jurisdictions, as well as prohibitively expensive.

- High-rate treatment devices (including disinfection) which can treat CSOs have a potential role in a long-term CSO control program, depending on the degree of CSO control deemed necessary. The costs are high and these technologies present operating problems. The tangible benefits are modest. Nevertheless, these technologies have merit in selective applications.

- Distributed storage tanks, i.e., distributed storage tanks or tunnel sewers, that capture most, but not all CSOs, have strong potential for a role in a long-term CSO control program. The capital costs are high but operating costs are relatively low. These facilities require substantial space but, with appropriate care, have been used successfully in sensitive land use areas, e.g., Toronto Beaches. These merit further study.

Area-wide real-time control should be considered as an enhancement to the inline and distributed storage options. As the volume of storage increased, so would the effectiveness and value at area-wide real-time control.

- Floatables control, such as trash netting or screening, has a potential role in a long-term program as an incremental control for optimizing the existing system if improved aesthetics control is a major objective. The costs can be relatively low and these measures could provide visible improvement in river water appearance.

6.0 SUMMARY

The preliminary conclusions with respect to screening the technologies are as follows.

Deletion of Options

- Complete separation of the existing combined sewer system is prohibitive in cost and is impractical on an area-wide basis due to widespread disruption of existing land use and does not warrant study in Phase 3. This conclusion is consistent with most CSO studies. The selective separation of pockets of combined sewers, for example, those near streams, will likely be cost-effective and will be identified in the basement flood protection studies.

- Area-wide storage systems, such as regional tunnel-transport systems to capture all CSOs, do not merit detailed study in Phase 3. Distributed storage is more cost-effective, less problematic in operation, more practical in terms of implementation and can provide similar benefits. Storage tunnels linking several districts may be effective, especially in areas with limited space and should be considered in Phase 3.

Candidate Options

- DWO corrections are the first priority in the water quality program.

- BMPs, including public education programs, should form part of any CSO control program.

- Disinfection of the WPCCs is the next logical step in any dry or wet weather program to address the coliform issue.

- Optimizing existing infrastructure through maximizing the existing Main Interceptor capacity and/or the capacity of the NEWPCC represents a cost-effective increment in CSO control, especially in combination with inline or offline storage. The specific ability of each district to utilize the potential in-line storage will need careful review before implementation (to avoid basement flooding). Increasing the transport capacity of the Main Interceptor and the capacity of the NEWPCC to deal with WWFs will need further study as to the ability to dewater storage within an appropriate timeframe and the appropriateness and effectiveness of real-time control.

- Distributed storage, either in the form of tanks or localized tunnels, or in single- or multi-district units, are potential methods of additional control if structurally intensive options are considered warranted for control of number or volume of CSOs. This technology is proven relatively cost-effective, and, if applied selectively, can avoid land-use and environmental concerns.

- High-rate treatment (single or multi-district) offers potential to serve effectively on a long-term CSO control program but capital and operating costs are high and the technology, particularly for VSS and UV disinfection process trains is still evolving. These have potential application if improved coliform control is the priority and should be carried forward for continuing evaluation in Phase 3.

- Floatables control, especially trash net technologies, could be a cost-effective way to improve aesthetic control for CSO, as an incremental control step over existing conditions or optimizing existing infrastructure, if control of aesthetics is the priority issue.

- A mix of control technologies will likely be required within the best overall plan, as some districts have a reasonable amount of space, in or around the outfall, to accommodate a storage tank, for example, while other districts apparently do not have any space.

Different "end-of-pipe" control options will need to be examined, as well as multi-district control facilities, to address these specific characteristics in Phase 3.

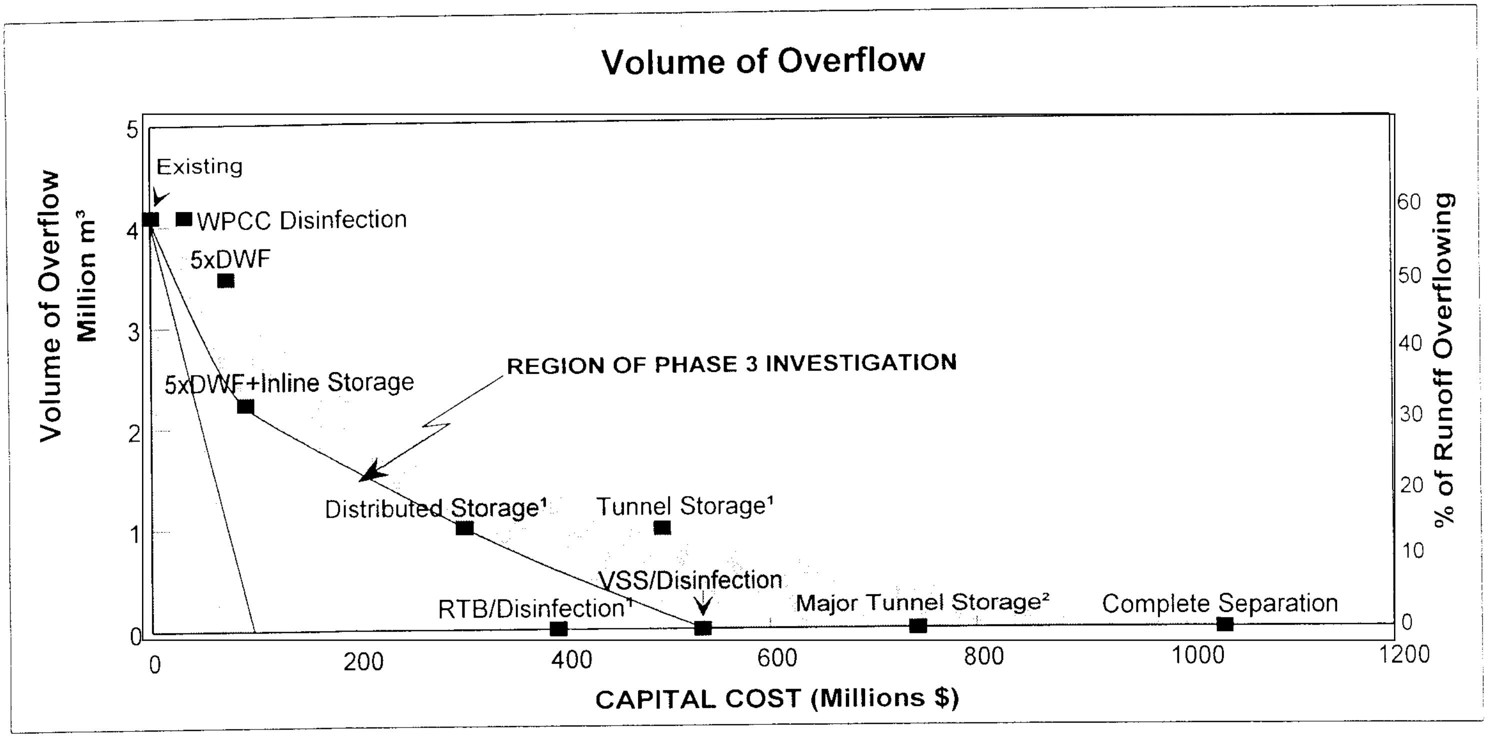
The Phase 2 screening addresses the technologies in conceptual terms. Specific application of the technologies will need further study in Phase 3. The evaluation results provide direction as to the focus of Phase 3 activities with respect to possible control technologies. This Phase 3 focus is shown on Figure 5-4. A schematic of the potential control strategies in conceptual terms is shown in Figure 5-5. The schematic shows that the overall CSO control program can take very different courses if the primary objective is to avoid aesthetic insult from CSOs, as opposed to achieving capture or treatment of most of the CSOs as a matter of good environmental policy or if the objective is to achieve marginal increases in overall compliance with coliform objectives.

Figure 5-5 illustrates that a number of important value judgement issues will need to be addressed as discussed in Section 7.

7.0 PUBLIC AND POLICY INPUT

The public and the policymakers must be important participants in defining the CSO control plan, particularly as it relates to defining the water quality objectives that it is willing support financially. In essence, the public should be informed on the impacts of CSOs and other discharges, on the beneficial uses of the river, the costs and benefits of the various control options, and then provide guidance to the City on their value judgements. This is a complex undertaking.

The benefits of disinfection on CSO control are not easily estimated. There will be no difference in the long-term appearance of the Rivers. For WPCC disinfection, for example, the potential benefits relate to better compliance with provincial coliform objectives, avoided health risk, improved aesthetics (with CSO controls) and improved public perception.


Volume of Overflow
Volume of Overflow Million m³
% of Runoff Overflowing
Existing
WPCC Disinfection
5xDWF
5xDWF+Inline Storage
REGION OF PHASE 3 INVESTIGATION
Distributed Storage¹
Tunnel Storage¹
VSS/Disinfection
RTB/Disinfection¹
Major Tunnel Storage²
Complete Separation
CAPITAL COST (Millions $)

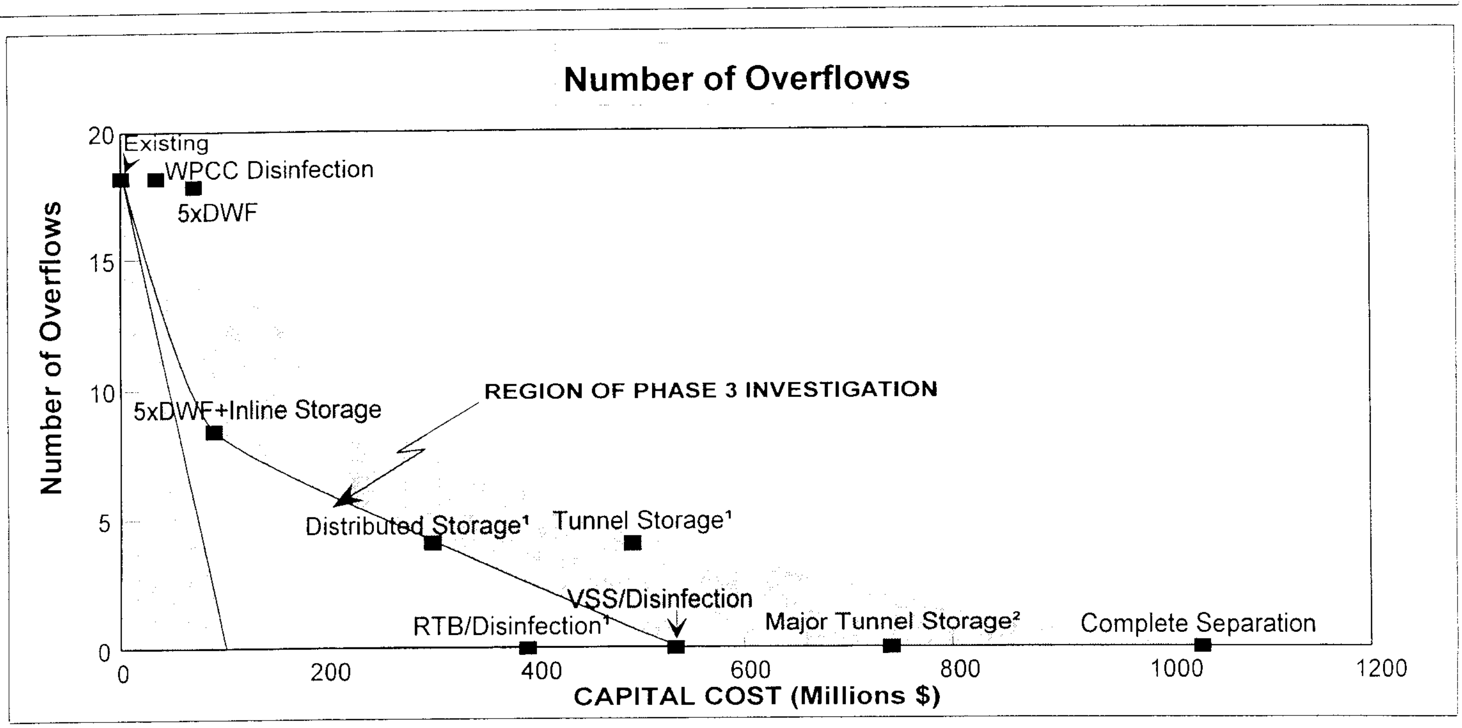
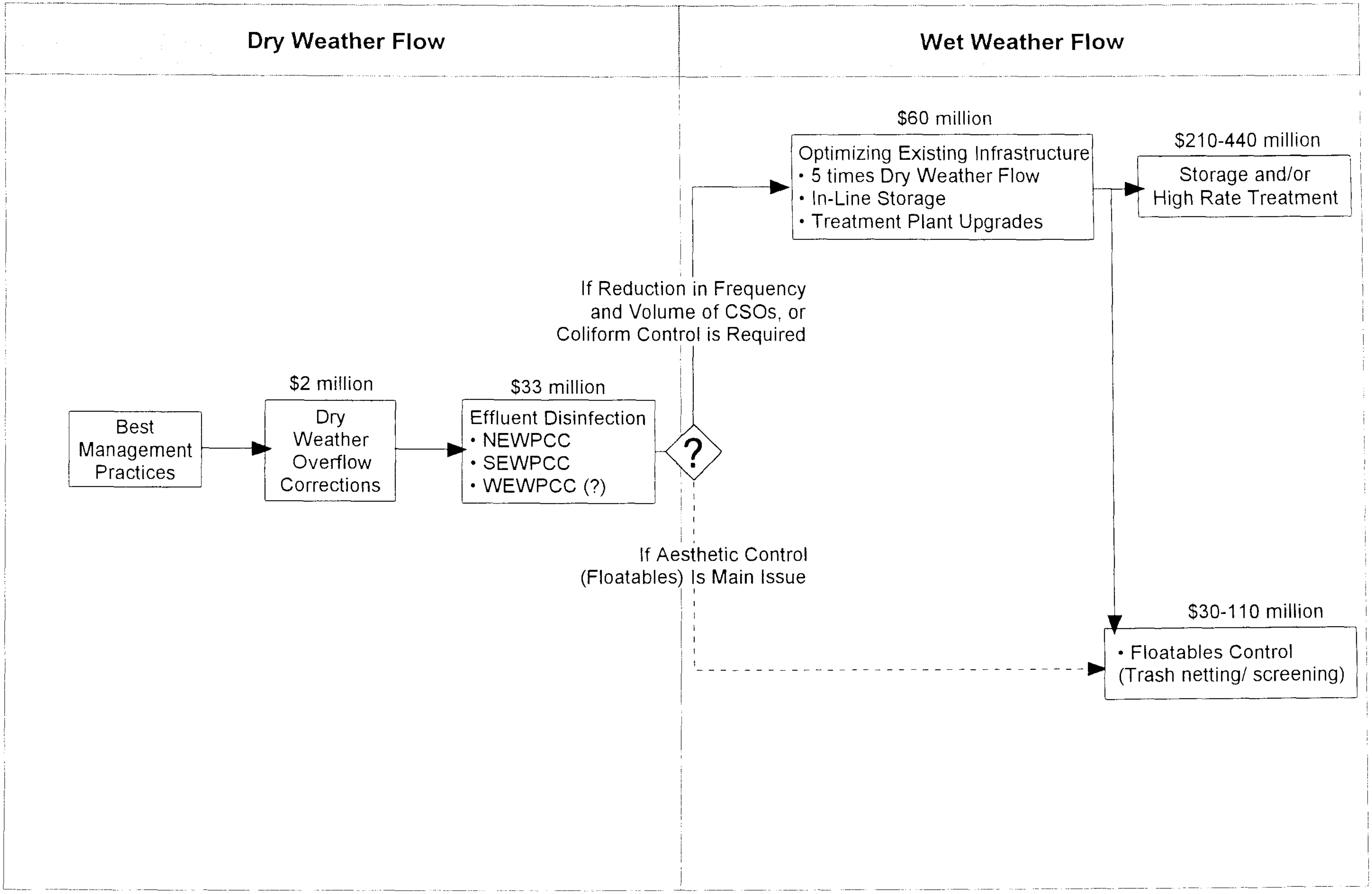

Number of Overflows
Number of Overflows
Existing
WPCC Disinfection
5xDWF
5xDWF+Inline Storage
REGION OF PHASE 3 INVESTIGATION
Distributed Storage¹
Tunnel Storage¹
VSS/Disinfection
RTB/Disinfection¹
Major Tunnel Storage²
Complete Separation
CAPITAL COST (Millions $)

Figure 5-4



Potential CSO Management Strategies

Figure 5-5

s:\01_files\0510_wrd\38_cso\ptctrlpn.DRW

The largest benefit of effluent disinfection or CSO control may be an improvement in public perception. Despite substantial upgrading and expansion of the NEWPCC and the SEWPCC, public concern about river water quality has apparently not been reduced in the last ten years. The results of a public attitude survey indicated that 90% of those polled were concerned about pollution in Winnipeg's Rivers. About 85% of respondents thought that the City was not doing enough to protect Winnipeg's Rivers. At this time, it is not possible to estimate the extent of the improvement in perception which would result from the disinfection of WPCC effluents or from CSO control.

The identifiable benefits of reducing health risk by disinfection of the City discharges are small in the context of the approximately 700,000 background cases of GI in the City from all causes and even in the context of the GI cases estimated to result from current recreational use of the Rivers. It is virtually impossible to assign a monetary value to these benefits.

Decision-makers should consider policies regarding the nature of the use of the local rivers for water-based recreation. Recent initiatives by governments including the City of Winnipeg are directed towards enhancing passive and secondary recreation river use. These include the construction of marina and dock facilities, and the sponsoring of river events such as motor boat racing. For these uses, microbiological quality is not significant in terms of health risk. The use of the Rivers for primary recreation is limited due to natural unsuitable characteristics. They are considered unsafe for swimming, with or without disinfection, by Winnipeg's Medical Health Officer. Waterskiing is a limited activity on the Red River. It is important to note that the recreational use of surface waters is not risk-free and that the number of cases of GI is largely a function of use, with or without disinfection. Public education and awareness can be an important factor in determining the water quality objectives acceptable to the public.

Policy matters relating to environmental responsibility must also be considered. Winnipeg discharges are an important reason that the river water exceeds the Manitoba microbiological Objectives. Disinfection of treatment plant effluents would improve the microbiological water quality of the Red and Assiniboine Rivers and would meet the objectives during dry weather but the objectives would continue to be exceeded during wet weather. Even with the very high costs associated with treating CSO, it will be difficult to achieve compliance with the objectives during wet weather. Public input is needed to determine what is acceptable to society. In this regard, the number of CSOs that are acceptable appears to be more important than a particular compliance with coliform objectives.

Several key questions emerge in considering the evolving alternative CSO control plans. These include:

- Should the dry weather objectives apply for wet weather conditions? After WPCC disinfection, compliance during dry weather will be achieved and, overall compliance, including WWF (e.g., moving from 95% to 96% compliance), has little relevance. A more practical measure would appear to be selection of the number or volume of CSOs that are acceptable.

- What degree of compliance with the coliform objective is deemed adequate (90%, 95%, 100%?).

- Should there be wet weather waivers of coliform objectives?

- What degree of CSO overflow control is acceptable (CSOs per season, 4?, 1?, 0?)

- What is the public prepared to pay for improved incremental control of WWF?

- How important is aesthetic control (floatables) compared to coliform control?

- Is it necessary to protect all reaches of the river to the same degree? Should the City prioritize a reach of the River, say the south leg of the Red River, for primary recreation, such as waterskiing?

The public will need to be involved in answering these questions. Accordingly, there will be ongoing activities to apprise the public of these important water quality management issues, as described in TM #5 Public. As well, ongoing dialogue with the regulatory agencies is planned in the ongoing phases of the study.