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# **Wastewater Effluent License Limits**

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# Effluent License Limits

## OUTLINE

- **Wastewater Treatment**
  - ◆ Background
- **Licensing Considerations**
  - ◆ Typical Effluent Parameters
  - ◆ Manitoba Conservation Limits
- **Design and Performance**
  - ◆ Biochemical Oxygen Demand
    - ▶ Dr. J. Oleszkiewicz – parameter selection
    - ▶ Performance History
    - ▶ River Monitoring
  - ◆ Total Suspended Solids
  - ◆ Microbiological
- **Appropriate Limits for Winnipeg**



# Effluent License Limits

## WASTEWATER TREATMENT

- **North End Water Pollution Control Center (NEWPCC)**
  - 1937: primary treatment
  - 1954: major plant expansion
  - 1965: secondary treatment
  - 1980: primary treatment expansion
  - 1984: secondary expansion convert to pure oxygen and computer control system
  - 1988: digesters expansion
  - 1990: dewatering building
- **South End Water Pollution Control Center (SEWPCC)**
  - 1974: conventional secondary plant
  - 1993: plant expansion
  - 1999: UV effluent disinfection
- **West End Water Pollution Control Center (WEWPCC)**
  - 1964: lagoons commissioned
  - 1976: mechanical plant (aeration) commissioned
  - 1994: new conventional secondary plant commissioned
  - 1998: ponds operated in summer and winter mode

# Effluent License Limits

## WASTEWATER TREATMENT

- Invested more than \$200 Million since 1978 in wastewater treatment
  - Modern state-of-the-art facilities
  - Almost entirely funded by sewer charges

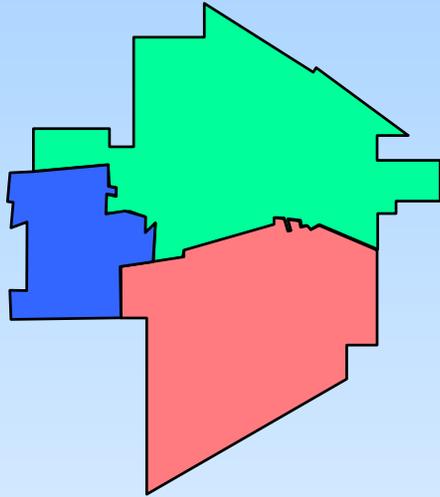


# Effluent License Limits

## WASTEWATER TREATMENT

- **All three Water Pollution Control Centers provide conventional secondary treatment**
  - Provides best practical secondary treatment
  - Designed to remove the carbonaceous content
  - 90 to 95 % removal of contaminants
  - 100% of dry weather flows
  - Natural physical and biological processes used in treatment
- **Disinfection of final effluent**
  - Ultraviolet disinfection in place at SEWPCC
  - Existing WEWPCC polishing ponds provide disinfection
  - NEWPCC planned for 2005

# Effluent License Limits



<b>Population Served</b>	<b>374,000</b>	<b>160,000</b>	<b>86,000</b>
<b>ADWF Recorded in 2002</b>	<b>160</b>	<b>50</b>	<b>27</b>
<b>ADWF Design Capacities</b>	<b>302</b>	<b>59</b>	<b>32</b>

*ADWF = Average Dry Weather Flow (ML/d)*

# Effluent License Limits

## LICENSING CONSIDERATIONS

- **Protect River's health and beneficial uses**
  - ◆ **Aquatic life**
    - ▶ Dissolved Oxygen (DO),
      - ▶ Relates to biochemical oxygen demand (BOD)
    - ▶ Other constituents,
      - ▶ Ammonia (NH<sub>3</sub>)
      - ▶ Total suspended solids (TSS)
      - ▶ Nutrients Nitrogen (N) and Phosphorus (P)
  - ◆ **Recreation**
    - ▶ Microbiological, Fecal coliforms (FC)



# Effluent License Limits

## LICENSING CONSIDERATIONS

- **Typical License Limits\* for Municipal Wastewater**
  - ◆ **Tier 1: Standards**
    - ▶ Secondary Treatment Technologies
  - ◆ **Implementation, effluent quality must achieve the following minimum standards (monthly average for compliance):**
    - ▶ 30 mg/L Biochemical Oxygen Demand BOD
    - ▶ 30 mg/L Total Suspended Sediments (excluding growing algae)
    - ▶ 200 fecal coliform organisms / 100 mL (may be applied on a seasonal basis)
  - ◆ ***Tier 2: Objectives***
    - ▶ *Ammonia (NH<sub>3</sub>), discussed earlier in detail*
  - ◆ ***Tier 3: Guidelines***
    - ▶ *Nutrients: Nitrogen (N) and Phosphorus (P) under review by Province*
    - ▶ *Discussed in Nutrient presentation*

\* - **Manitoba Conservation: Manitoba Water Quality Standards, Objectives, and Guidelines, Final Draft November 22, 2002**

# Effluent License Limits

## LICENSING CONSIDERATIONS

- **All three Water Pollution Control Centers designed to achieve effluent quality of:**
  - **30 mg/L Total Suspended Solids (TSS)**
  - **25 mg/L 5-day Carbonaceous Biochemical Oxygen Demand (CBOD<sub>5</sub>)**
- **Use of Carbonaceous BOD measure different from parameter put forward by Province**
  - **Engaged Dr. J. Oleszkiewicz to review situation**

# Effluent License Limits

## PARAMETER REVIEW

- **Dr. J. Oleszkiewicz, P.Eng, C.Eng(UK)  
Diplomate, American Academy of  
Environmental Engineers**
  - **25 years of regulatory, consulting, research and academic experience in water pollution control and waste treatment**
  - **International consulting work**
  - **Specialized CBOD vs. TBOD work in Ontario**
  - **Professor of Environmental Engineering at University of Manitoba since 1983**

# Effluent License Limits

## LICENSING OF DISCHARGES

- Manitoba Conservation historically used TBOD (Total BOD without inhibition of nitrification)
- Plant operation and design based on CBOD (Carbonaceous BOD with inhibited nitrification)
- Most provinces use CBOD
- The need for License based on CBOD warrants discussion

# Effluent License Limits

**CBOD represents the actual performance of a plant and its true impact on the river**

$$\text{BOD}_{\text{total}} = \text{BOD}_{\text{Carbon in organics}} + \text{BOD}_{\text{Nitrogen}}$$

$$\text{TBOD} = \text{CBOD} + \text{NBOD}$$

# Effluent License Limits

## WHAT IS BOD?

- **BOD: Biochemical Oxygen Demand was developed over a century ago\* to measure the ability of bacteria to degrade organic matter in sewage and river waters after 5 day incubation at 20°C**
- **It measures the consumption of dissolved oxygen by bacteria**
  - **Introduced as seed with dilution water containing ammonia and nutrients**
  - **Does not measure the organic pollutants directly**
- **Why 5 days?**
  - **Rivers in England reached the sea in 5 days or less**

*\* Baird & Smith: "Third century of biochemical oxygen demand", WEF 2002*

# Effluent License Limits

## EFFLUENT BOD: HISTORY

- US EPA set up 30 mg/L TBOD effluent limit in late 70's; based on 85% removal requirement for the secondary plants
  - ✦ Non-compliance was reported for 60% of plants
- EPA found that non-compliance was:
  - ✦ **artifact of the testing method**, and
  - ✦ **recommended** CBOD of 25 mg/L for all wastewater plants with secondary treatment
- CBOD test was developed that inhibits ammonia nitrogen oxidation:
  - ✦ *“ inclusion of ammonia in dilution water, demonstrates that BOD test is not intended to include oxygen demand of nitrogen in the BOD test ”*

# Effluent License Limits



## USA

- **Most states e.g., IN, IL, MN, NJ, PA, FL and other converted to CBOD by the early 1990's (effluent permits of 20-25 mg/L CBOD)**
- **N. Dakota still uses TBOD but considers the switch to CBOD, to be in line with Minnesota which uses CBOD.**
- **E. Grand Forks, Moorhead use CBOD**

# Effluent License Limits



## EUROPEAN UNION

- Started with TBOD (1991 Wastewater Directive) and ran into problems
- 1998 European Union **banned** the use of TBOD, **allowing** the use of CBOD
  - ISO 5815 Norm
- Some countries (e.g. France, UK, Poland) allow the use of an instrumental rapid biosensor method which registers CBOD\*

\* Marty et al: *Measurement of BOD: correlation between 5-day BOD and commercial BOD biosensor values. Environm. Technol., 18: 333-337, 1997*

# Effluent License Limits



## CANADA

- Most provinces switched to CBOD (e.g. Ontario 1996) or used it all along (e.g. Alberta)
- BC still uses TBOD but will be switching to CBOD shortly
- Ontario Ministry of Environment recommended:
  - ➔ “ *25 mg/L CBOD; measure TAN, TKN and address ammonia toxicity* ”

# Effluent License Limits

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## WHY USE CBOD?

- **Effluent quality expressed in CBOD reflects the true impact on the river**
- **CBOD does not measure nitrogen, which is added to the test bottle**
- **Most Regulators use CBOD**
- **Secondary wastewater treatment plants are designed and operated based on CBOD**

# Effluent License Limits

## NEWPCC CBOD<sub>5</sub> PERFORMANCE

Inhibited Effluent: Monthly Averages of CBOD<sub>5</sub> (mg/L)

Year	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
1992	17	14	12	9	9	9	9	9	6	9	7	7
1993	9	7	8	6	7	5	6	6	6	7	6	9
1994	11	12	11	10	9	9	9	8	6	9	12	12
1995	13	12	27	11	12	15	16	15	13	13	13	14
1996	14	11	11	20	13	11	13	12	12	12	10	11
1997	10	13	14	21	19	11	11	10	11	11	11	11
1998	11	15	10	12	14	11	13	10	11	9	10	10
1999	15	18	18	12	13	11	9	9	10	10	12	12
2000	10	10	6	10	12	9	10	13	10	11	12	16
2001	12	12	14	10	9	8	10	9	10	10	10	13
2002	12	11	15	13	12	10	10	12	9	9	11	13

	Exceeds 25 mg/L Compliance Limit
	No Data, Compliance uncertain
	Meets 25 mg/L Compliance Limit

# Effluent License Limits

## SEWPCC CBOD<sub>5</sub> PERFORMANCE

Inhibited Effluent: Monthly Averages of CBOD<sub>5</sub> (mg/L)

Year	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
1992	9	17	14	13	11	10	12	16	11	14		
1993		23	10	11	10	11	11	10	11	11	10	10
1994	12	10	15	11	15	10	10	10	11	12	10	11
1995	11	12	10	11	10	11	10	10	11	10	10	11
1996	19	21	11	10	10	10	12	10	10	10	11	11
1997	10	10	10	10		17	10	10	10	10	10	11
1998	13	14	13	11	13	12	14	12	7	6	6	6
1999	32	41	23	10	8	5	5	6	7	9	9	13
2000	9	10	6	7	6	8	6	5	6	6	7	8
2001	6	8	12	8	7	10	7	6	6	6	7	7
2002	9	6	6	8	10	6	5	4	5	5	6	4

	Exceeds 25 mg/L Compliance Limit
	No Data, Compliance uncertain
	Meets 25 mg/L Compliance Limit

# Effluent License Limits

## WEWPCC CBOD<sub>5</sub> PERFORMANCE

Inhibited Pond Effluent: Monthly Averages of CBOD<sub>5</sub> (mg/L)

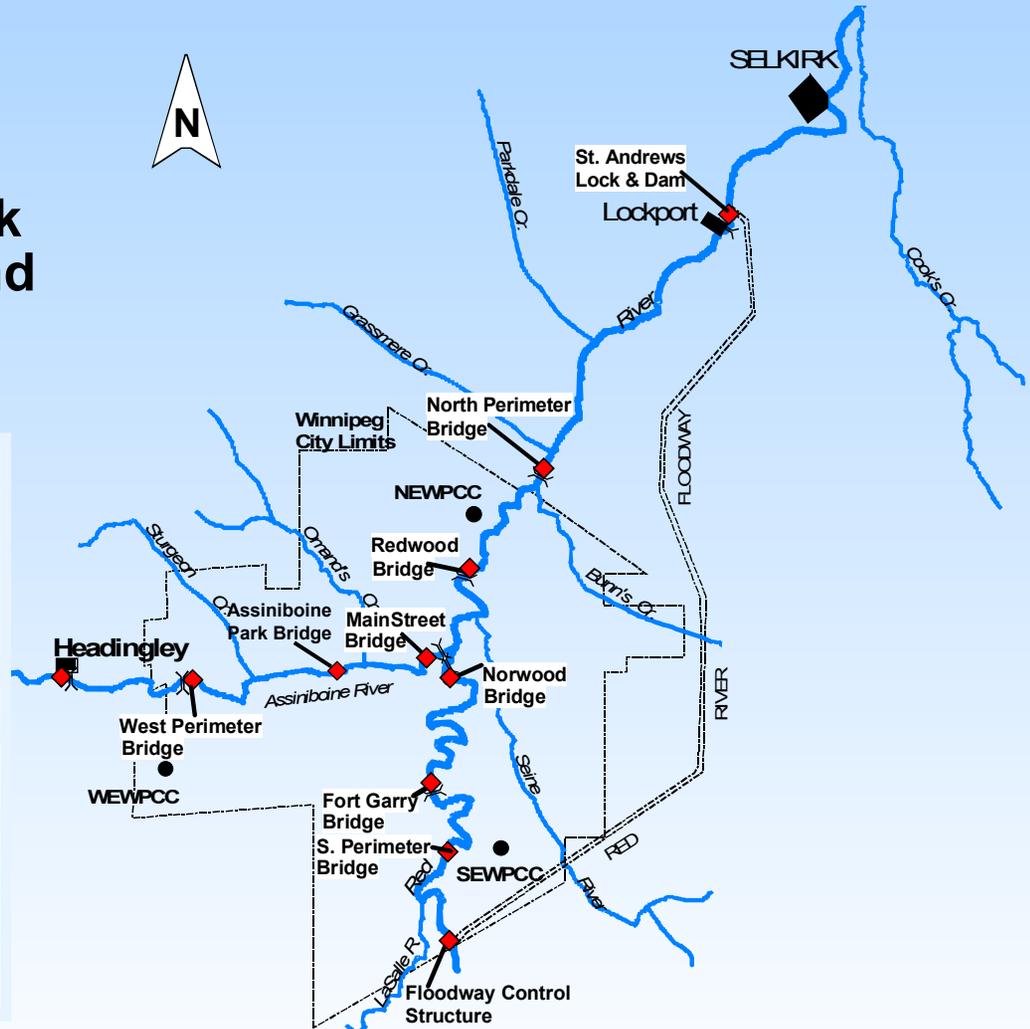
Year	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
1998			15	17	14		14	12	6	5	6	7
1999	12	9	13	13	14	11	11	8	11	12	18	19
2000	12	11	15	21	13	7	8	8	6	12	10	9
2001	6	6	13	11	17	9	7	8	6	11	11	8
2002	8	6	9	6	17	8	6	10	8	11	11	10
Winter Operation				Summer Operation					Winter Operation			

	Exceeds 25 mg/L Compliance Limit
	No Data, Compliance uncertain
	Meets 25 mg/L Compliance Limit

# Effluent License Limits

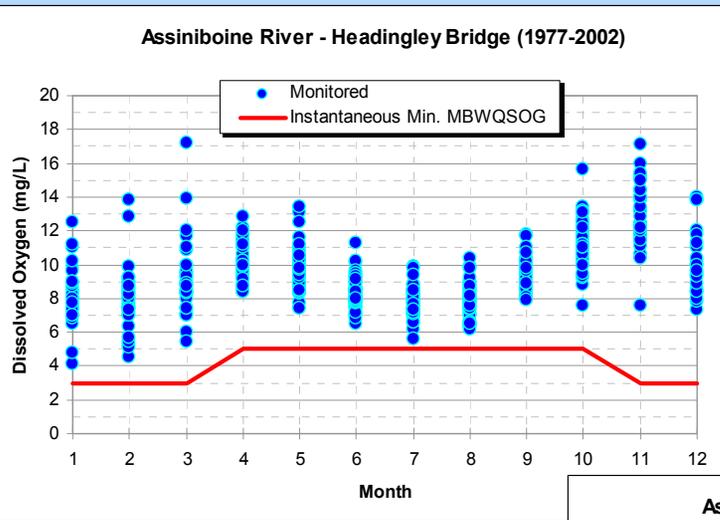
## RIVER MONITORING

The City of Winnipeg has conducted year-round bi-week water sampling on the Red and Assiniboine since 1977 at 11 bridge locations as shown



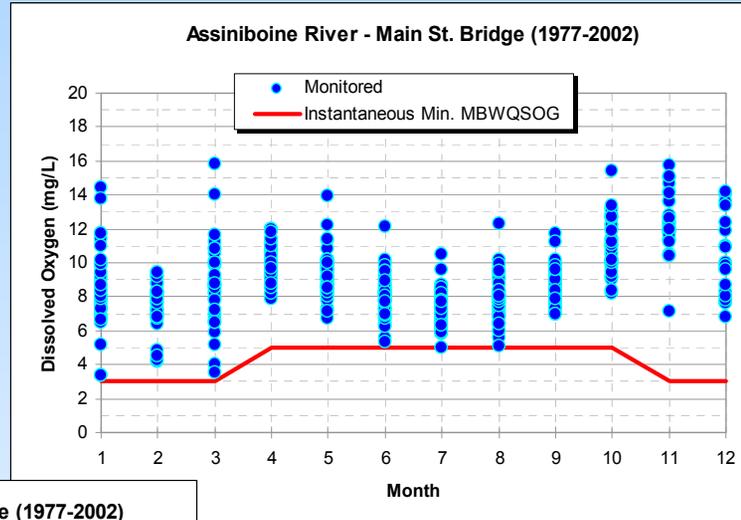
# Effluent License Limits

## MONITORED DO LEVELS – ASSINIBOINE RIVER

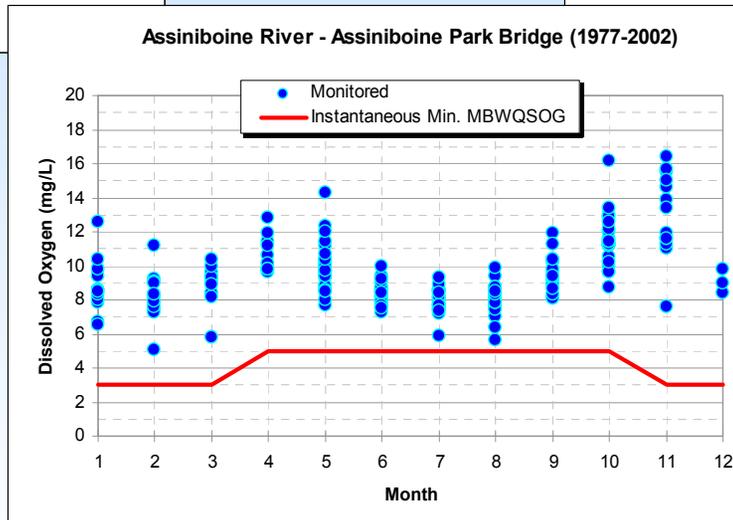


1

2



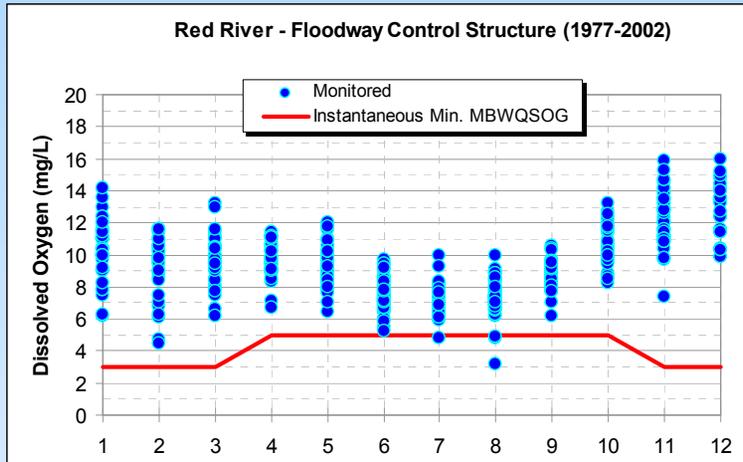
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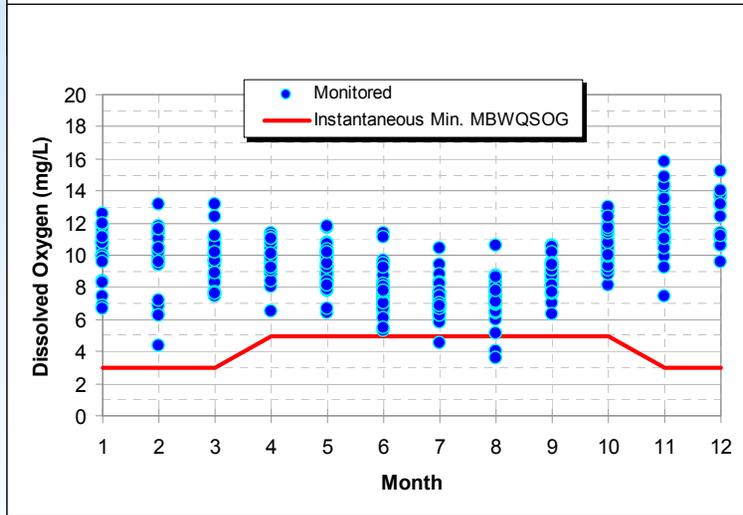
# Effluent License Limits

## MONITORED DO LEVELS – RED River

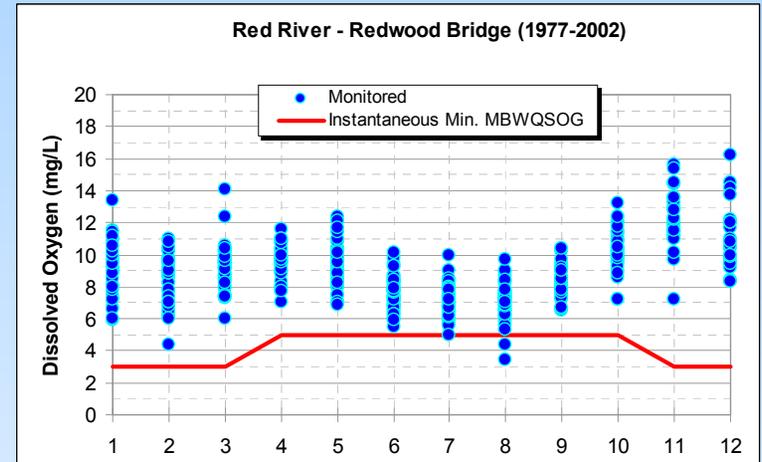
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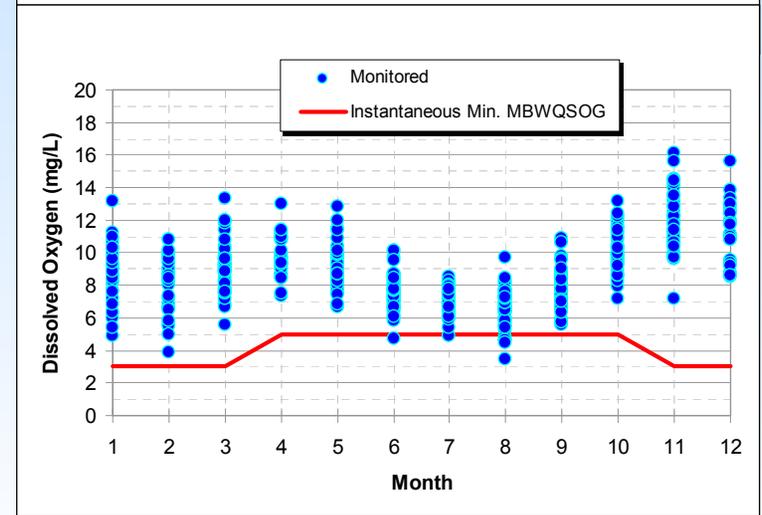
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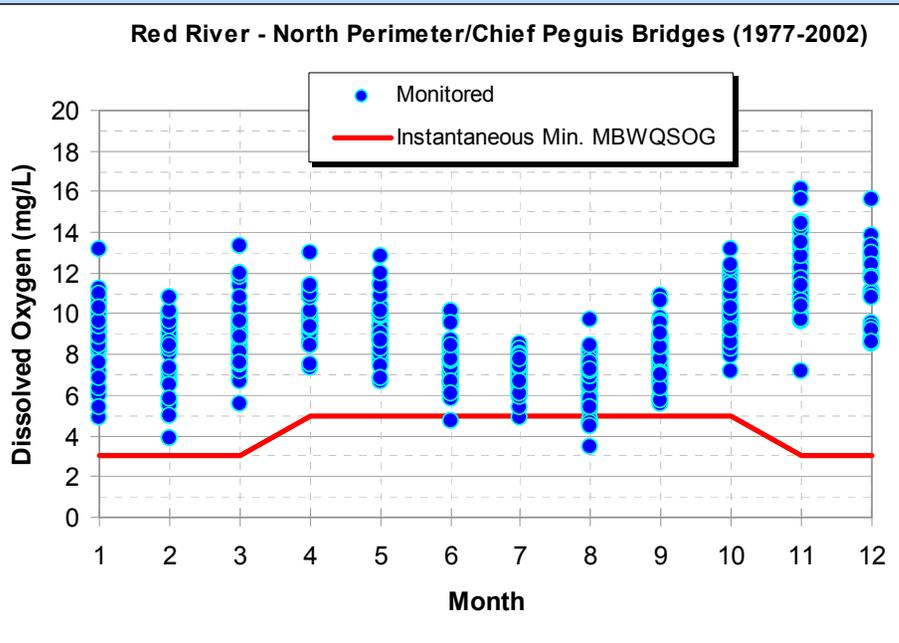


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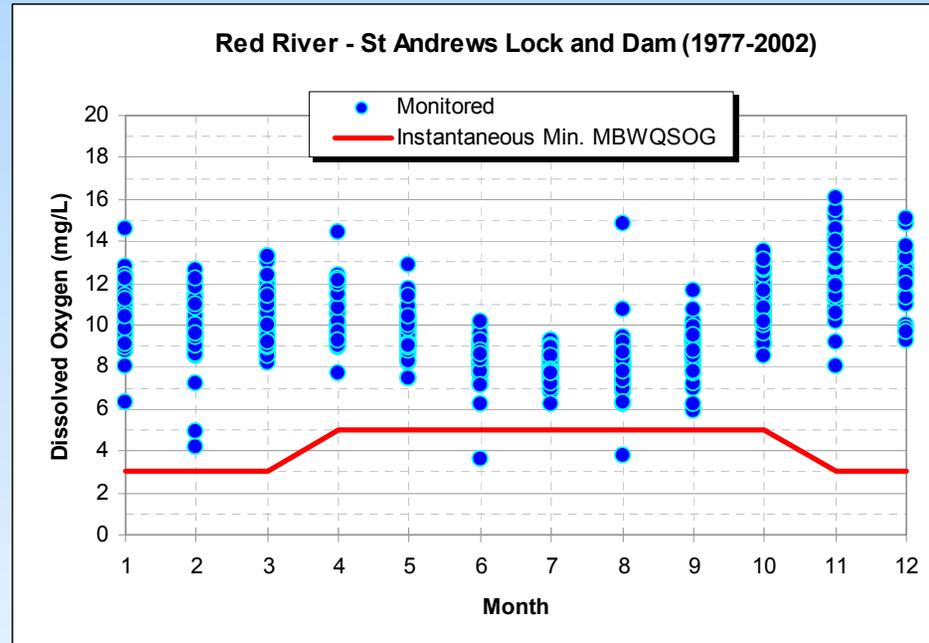


# Effluent License Limits

## MONITORED DO LEVELS – RED RIVER



4



5

# Effluent License Limits

## HEALTHY DO LEVELS

- Existing design and operational performance of the WPCCs are adequately protecting dissolved oxygen resources of the Rivers
- A limit of 25 mg/L as measure by effluent CBOD<sub>5</sub> on a monthly average basis is an appropriate License compliance condition for Winnipeg's wastewater treatment plants
  - Consistent with other jurisdictions

# Effluent License Limits

## NEWPCC TSS PERFORMANCE\*\*

Effluent: Monthly Average of Total Suspended Solids (mg/L)

Year	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
1992	29	20	27	26	23	27	29	31	15	20	18	22
1993	25	15	18	14	19	16	25	25	13	11	10	13
1994	15	13	17	15	16	18	28	20	13	21	16	16
1995	18	13	40	15	17	26	27	35	19	19	15	23
1996	23	11	14	53	29	25	16	30	20	23	25	20
1997	15	30	34	54	66	21	19	18	18	25	21	22
1998	16	26	18	19	26	25	31	20	21	15	18	19
1999	29	35	33	26	32	24	23	21	20	20	19	17
2000	19	14	10	17	23	23	29	24	15	19	19	34
2001	14	18	18	17	19	14	21	18	16	19	13	24
2002	21	17	26	25	21	19	21	26	16	9	14	18

	Exceeds 30 mg/L Compliance Limit
	No Data, Compliance uncertain
	Meets 30 mg/L Compliance Limit

\*\* Note: Monitored final effluent includes wet weather by-pass of secondary treatment.

Performance results to be reported on secondary treated effluent

# Effluent License Limits

## SEWPCC TSS PERFORMANCE\*\*

Effluent: Monthly Average of Total Suspended Solids (mg/L)

Year	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
1992	23	29	21	16	14	12	15	18	14	14		
1993	24	18	7	13	9	15	18	14	24	16	16	14
1994	13	11	17	10	17	7	10	9	10	11	9	8
1995	8	11	9	5	6	15	5	6	12	7	7	8
1996	16	16	12	8	10	8	6	7	6	7	13	9
1997	6	7	7	6		9	6	6	10	6	8	9
1998	11	23	15	13	19	13	10	11	11	14	13	10
1999	36	37	30	18	14	11	10	10	10	11	11	19
2000	12	17	9	10	10	14	11	9	7	7	7	8
2001	9	8	13	14	14	15	14	9	8	11	10	11
2002	11	10	14	29	44	10	10	9	15	8	7	9

	Exceeds 30 mg/L Compliance Limit
	No Data, Compliance uncertain
	Meets 30 mg/L Compliance Limit

\*\* Note: Monitored final effluent includes wet weather by-pass of secondary treatment.

Performance results to be reported on secondary treated effluent

# Effluent License Limits

## WEWPCC TSS PERFORMANCE\*\*

Pond Effluent: Monthly Average of Total Suspended Solids (mg/L)

year	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
1998			15	49	47		31	34	21	12	13	8
1999	16	13	17	31	43	44	29	21	12	24	30	24
2000	10	12	19	34	23	20	26	37	27	26	22	14
2001	7	8	15	19	29	21	17	11	12	20	15	9
2002	8	14	11	12	28	19	18	30	22	22	16	8
Winter Operation				Summer Operation					Winter Operation			

	Exceeds 30 mg/L Compliance Limit
	No Data, Compliance uncertain
	Meets 30 mg/L Compliance Limit

\*\* Note: Monitored final effluent may include algae and/or re-suspended solids from spring melt conditions

Performance results to be reported on secondary treated effluent

# Effluent License Limits

- **Minor exceedance of Total Suspended Solids limit of 30 mg/L, as measure on a monthly average, does not adversely affect aquatic life in local rivers.**
- **River has a naturally high sediment concentration, which is much greater than effluent discharge concentrates**
  - ◆ **Typical local river concentrations, 85 to over 200 mg/L, during open water entering Winnipeg**

# Effluent License Limits

## SEWPCC EFFLUENT DISINFECTION

- **Disinfection implemented at SEWPCC to achieve substantial compliance with Manitoba's Surface Water Microbiological Objective under normal operating conditions:**
  - **Using Ultraviolet technology**
  - **Compliance target of 200 FC/100mL up to 100 ML/d**
  - **Compliance based on end-of-pipe effluent quality**
  - **Seasonal operation, May 1 to Sept 30 inclusive**
  - **Wet weather and high river level exclusions**
  - **In operation since July 1999**
  - **Detailed reporting provided to MB conservation**

# Effluent License Limits

## SEWPCC EFFLUENT SUMMARY: FECAL COLIFORMS

### *SEWPCC Average<sup>1</sup> Monthly Effluent Bacteriological Quality*

Year	2002	2001	2000	1999
Month	Fecal Coliform <sup>2</sup>	Fecal Coliform <sup>2</sup>	Fecal Coliform <sup>2</sup>	Fecal Coliform <sup>2</sup>
May	39	41	14	
June	31	419	81	
July	175	972	89	62
August	63	208	32	73
September	304	425	61	39

(1) Geometric mean

(2) Most Probable Number (MPN) per 100 mL

	Exceeds 200 FC/100 mL Compliance Limit
	No Data, Compliance uncertain
	Meets 200 FC/100 mL Compliance Limit

- **Problem related to premature UV lamp failure**

# Effluent License Limits

## WEWPCC EFFLUENT DISINFECTION

- **WEWPCC operation different than NEWPCC and SEWPCC**
  - ◆ **Plant design and operation similar to SEWPCC**
  - ◆ **Retained the use of polishing ponds as storage cells**
    - ▶ **Continues to polish wastewater and improve effluent quality, especially fecal coliform levels**
  - ◆ **Need for additional disinfection of WEWPCC effluent unlikely**
    - ▶ **Modifications made to treatment train has resulted in effluent quality that achieves significant compliance with fecal coliform objective**
    - ▶ **Need for additional disinfection to be assessed through continued effluent monitoring and compliance reporting**

# Effluent License Limits

## WEWPCC EFFLUENT SUMMARY: FECAL COLIFORMS

### *WEWPCC Average<sup>1</sup> Monthly Effluent Bacteriological Quality*

Year	2002	2001	2000	1999	1998
Month	Fecal Coliform <sup>2</sup>				
May	116	11	6	25	
June	6	2	10	8	
July	11	15	5	8	11
August	54	57	146	25	59
September	74	27	174	210	285

(1) *Geometric mean*

(2) *Most Probable Number (MPN) per 100 mL*

	Exceeds 200 FC/100 mL Compliance Limit
	No Data, Compliance uncertain
	Meets 200 FC/100 mL Compliance Limit

# Effluent License Limits

## NEWPCC EFFLUENT DISINFECTION

- **Disinfection to be implemented at NEWPCC:**
  - ◆ **Existing plant reduces Fecal coliform (FC) significantly, but doesn't meet microbiological objective**
    - ▶ "Raw", typical Influent: ~ 10,000,000 FC/100 mL
    - ▶ "Treated", typical effluent: ~ 250,000 FC/100 mL
    - ▶ Disinfected effluent: ~ 200 FC/100mL or less
  - ◆ **Will be designed to achieve significant compliance with microbiological objective under normal operating conditions, similar to SEWPCC.**
    - ▶ Compliance with 200 FC/100mL will be assessed
    - ▶ CSO plans will influence design requirements and operation
    - ▶ Seasonal operation, May 1 to Sept 30 inclusive
  - ◆ **Will be in operation for 2005 summer recreation season.**
    - ▶ City has committed \$15 Million for facility

# Effluent License Limits

## LICENSING CONSIDERATIONS

- **Recommended License limits and conditions for treated secondary effluent:**
  - **Carbonaceous BOD**
    - ▶ Standard, Tier 1
    - ▶ Base on protecting river Dissolved Oxygen content
    - ▶ Monthly average to achieve 25 mg/L with excursions to be addressed
  - **Total Suspended Solids**
    - ▶ Objective, Tier 2
    - ▶ Monthly average to achieve target of 30 mg/L
    - ▶ Excursions in accordance with MWQSOG (final draft +/- 25 mg/L)
    - ▶ Exclude algae from ponds
  - **Fecal Coliforms**
    - ▶ Generally consistent with current SEWPCC License conditions
    - ▶ Specifics to be review as part of disinfection project for NEWPCC
  - **Nutrients**
    - ▶ Premature to establish limits at this time