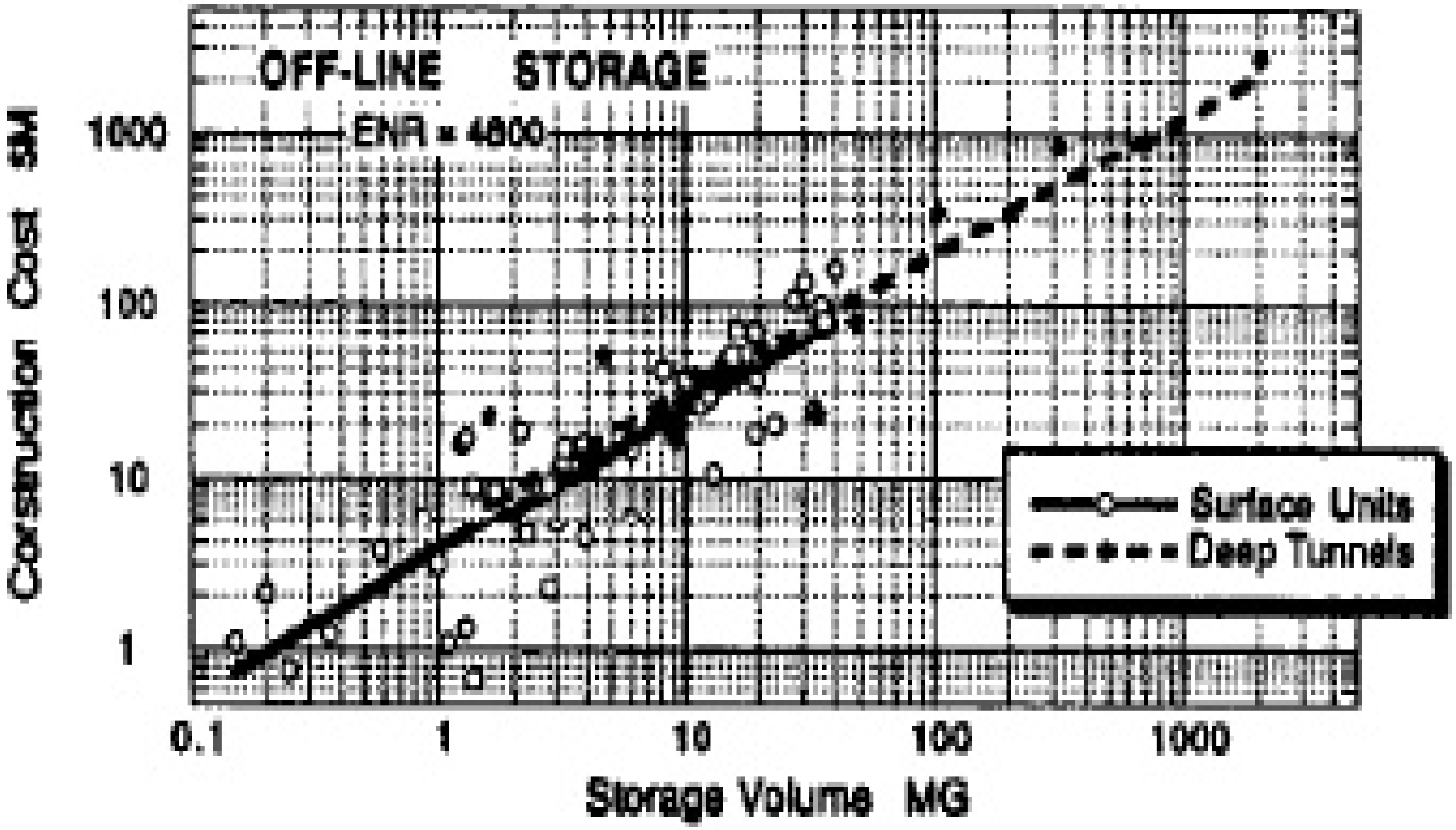
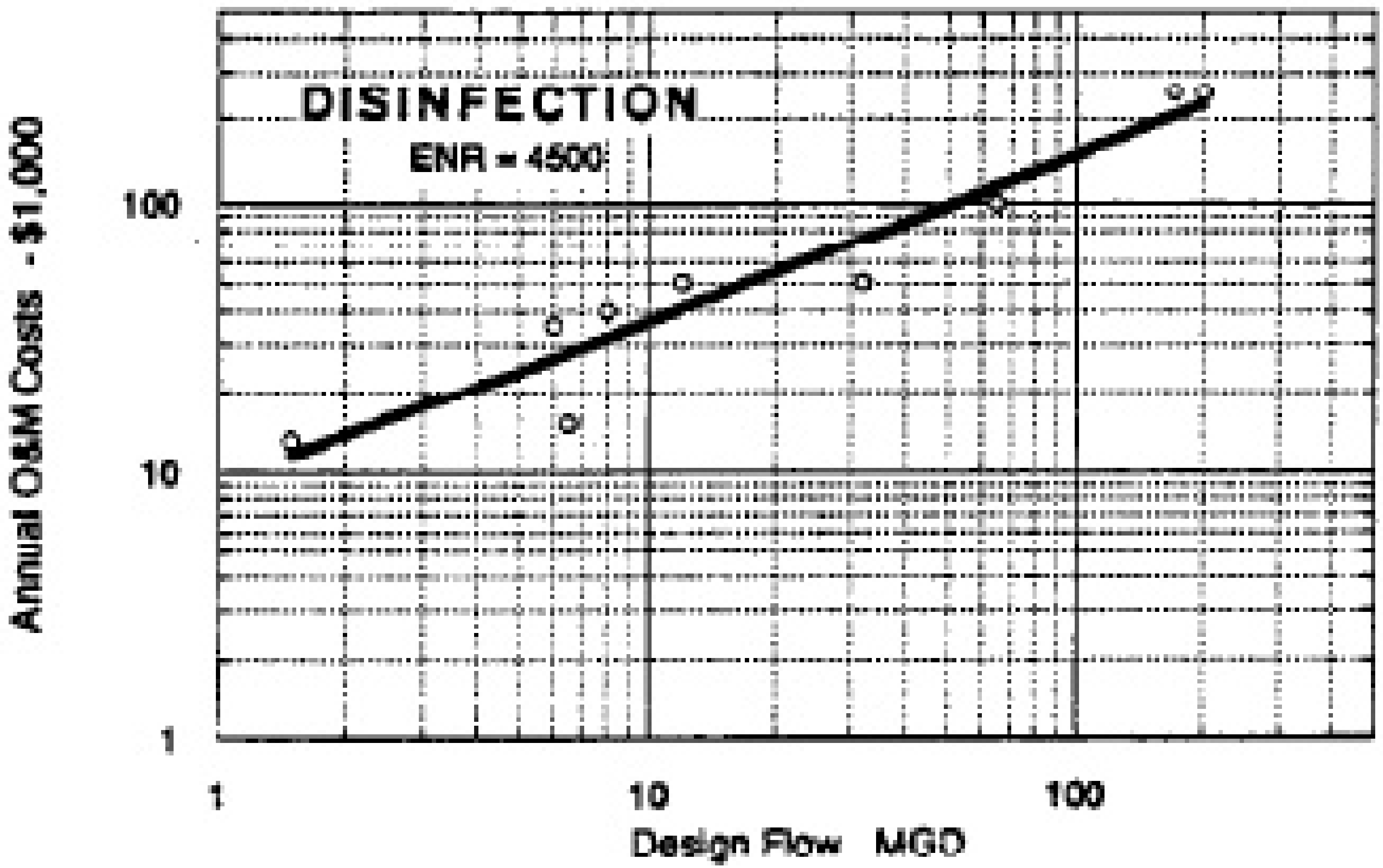
Appendix 7-1: 2004 LTCP Cost Estimating Backup



Source: *USEPA Combined Sewer Overflow Control Manual* (EPA/625/R-93/007, September 1993)



Source: *USEPA Combined Sewer Overflow Control Manual* (EPA/625/R-93/007, September 1993)

McMahon & Mann 2495 Main Street, Suite 432 • Buffalo, New York 14214
Consulting Engineers, P.C.

Donald R. McMahon, P.E.
Michael J. Mann, P.E.
Thomas R. Heins, P.E.
Kenneth L. Fishman, Ph.D., P.E.
James Bojarski, P.E.
Shawn W. Logan, P.E.
Andrew J. Nichols, P.E.
Todd W. Swackhamer, P.E.

January 9, 2003
File: 03-036

Mr. Ronald R. Cavalieri, P.E.
Malcolm Pirnie, Inc.
40 Centre Drive
Orchard Park, New York 14127

RE: Summary of Tunnel Cost Comparisons,
Combined Sewer Overflow Abatement Program,
Buffalo, New York

Dear Mr. Cavalieri;

McMahon & Mann Consulting Engineers, P.C. (MMCE) has reviewed the Malcolm Pirnie Inc. (MPI) proposed program for the Buffalo Sewer Authority's Combined Sewer Overflow Abatement Program and has prepared an opinion of probable construction costs for three different rock tunnels with three different finished diameters.

MPI has proposed three tunnels constructed in rock to store combined sewerage during storm events. The Scajaquada Tunnel will be about 14,200 feet long, located along Scajaquada Creek, east of Main Street. The Buffalo River Tunnel will be about 26,000 feet long and will extend from near the confluence of the Buffalo River and Cazenovia Creek to Downtown Buffalo. The Black Rock Tunnel will be about 7,400 feet long and will parallel the Black Rock Channel.

The results of our analyses are presented in the following tables. The assumptions made to develop these opinions are listed following the tables.

CONSTRUCTION COSTS

The following tables summarize the construction costs for the three tunnels with the different finished diameters.

SCAJAQUADA TUNNEL (length = 14,200 feet, five shafts)

ITEM	10-foot Diameter	15-foot Diameter	20-foot Diameter
Mobilization ($M) [1]	3.7	5.5	9.3
Shaft (each, $1000) [2]	96	181	338
Bore with Lining ($ per foot) [3]	1,584	2397	3418

Note 1: Costs are presented in millions
Note 2: Costs presented are in thousands
Note 3: Costs presented are dollars per foot of tunnel

BUFFALO RIVER TUNNEL (length = 26,000 feet, four shafts)

ITEM	10-foot Diameter	15-foot Diameter	20-foot Diameter
Mobilization ($M)	6.4	9.5	13.0
Shaft (each, $1000)	224	430	447
Bore with Lining ($ per foot)	1310	2044	2589

BLACK ROCK TUNNEL (length = 7,400 feet, three shafts)

ITEM	10-foot Diameter	15-foot Diameter	20-foot Diameter
Mobilization ($M)	2.1	3.1	4.5
Shaft (each, $1000)	188	394	527
Bore with Lining ($ per foot)	2138	3154	4141

MMCE also compared the total estimated construction costs for the three different tunnels and the cost per unit volume of storage capacity, as shown below.

TUNNEL		10-foot Diameter	15-foot Diameter	20-foot Diameter
Scajaquada	Total Cost ($M)	26.7	40.6	59.7
(14,200 ft.)	Volume (Mgal.)	8.3	18.8	33.3
	Cost, $/Gallon	3.20	2.16	1.79
Buffalo River	Total Cost ($M)	41.4	64.5	82.3
(26,000 ft.)	Volume (Mgal.)	15.3	34.4	61.1
	Cost, $/Gallon	2.71	1.88	1.35
Black Rock	Total Cost ($M)	18.5	27.8	37.2
(7,400 ft.)	Volume (Mgal.)	4.3	9.8	17.4
	Cost, $/Gallon	4.26	2.84	2.14

ASSUMPTIONS

MMCE made many assumptions to develop the construction costs summarized above. The primary assumptions are listed below.

Tunnel Diameter - The excavated tunnel diameter is 2 feet greater than the finished diameters shown above. Each tunnel has a 12-inch thick concrete lining.

Tunnel Excavation – An electric tunnel boring machine (TBM) will be used with mine tracks, locomotives and muck cars to excavate and remove the spoil from each tunnel The contractor will purchase a new TBM, locomotives and rail cars for each contract. We have considered no salvage value on the equipment.

Tunnel Support – We have considered that rock bolts will be used for supporting the tunnels and that ribs will be required for a portion of the tunnel length.

Shafts - The number of shafts are listed above for each tunnel. The diameter of each shaft in rock is greater than the diameter of the tunnel and the shaft diameter in soil is greater than that in rock. The depth of each shaft was estimated to provide about one tunnel diameter plus 2 feet of rock cover above the tunnel at the deepest top of rock depth. The estimated depth to top of rock along the tunnels was provided by MPI.

Shaft Support - The shaft in the overburden will be supported with braced steel sheet piles The shaft in the rock will be supported with shotcrete.

Labor – We used current Erie County prevailing wage rates for developing the opinions of construction costs.

LIMITATIONS

MMCE developed the above opinions of probable construction costs, based on the preliminary information provided by MPI and the assumptions listed above. Actual construction costs depend on many factors including market conditions, final design details and others not considered. They will differ from the costs described herein

We appreciate the opportunity to participate on this interesting project and look forward to working together again. We will call in a few days to discuss any questions.

Sincerely yours,

McMAHON & MANN CONSULTING ENGINEERS, P.C.

Donald R. McMahon, P.E.

FAX TRANSMISSION

Koester Associates, Inc.

Fax (315) 697-3888
Phone (315) 697-3800
RR#5 Box 620, Suite 7, Madison Blvd.,
Canastota, NY 13032
info@koesterassociates.com

Date: January 30, 2004

From: Mark Koester

This fax contains (3) pages, including this page.

Name: Dave Millar
Company: Malcolm Pirnie
Fax Number: 716-667-0279

Cc: Mike Gutshall
Matt Cotton

Subj: Buffalo Sewer Authority
ACTIFLO Unit Cost Estimate

Dave,

Let's try this one more time. Attached is a copy of our original spreadsheet outlining the 1-Month EHRC Size, Total Installed Cost and Yearly O&M Cost. The Yearly O&M Cost is based on the following:

- 30 day/year operation
- 25 MGD or less per train
- Estimated daily O&M cost per the Kruger options 1 through 11
- 50 man hours/year per train
- $60 per man hour

1-Month EHRC Size (MGD)	Total Installed Cost ($)	Yearly O&M Cost ($)
0	0	0
15	4,500,000	38,046
7.5	3,000,000	20,491
10	4,000,000	26,213
0	0	0

Koester Associates, Inc.

2	800,000	7,857
10	4,000,000	8,213
15	4,500,000	38,046
50	12,500,000	121,100
0	0	0
0	0	0
2	800,000	7,857
10	4,000,000	26,213
0	0	0
0	0	0
7.5	3,000,000	20,491
1	400,000	5,547
15	4,5000,000	38,046
0	0	0
0	0	0
1	400,000	5,547
0	0	0
0	0	0
0	0	0
3	1,200,000	9,975
0	0	0
0	0	0
0	0	0
25	7,500,000	61,431
0	0	0
50	12,500,000	121,100
4	1,600,000	12,114
0	0	0
25	7,500,000	61,431
50	12,500,000	121,100
50	12,500,000	121,100
0	0	0
3	1,200,000	9,975
200	40,000,000	484,400
0	0	0
0	0	0
0	0	0
1	400,000	5,547
1	400,000	5,547
15	4,500,000	38,046

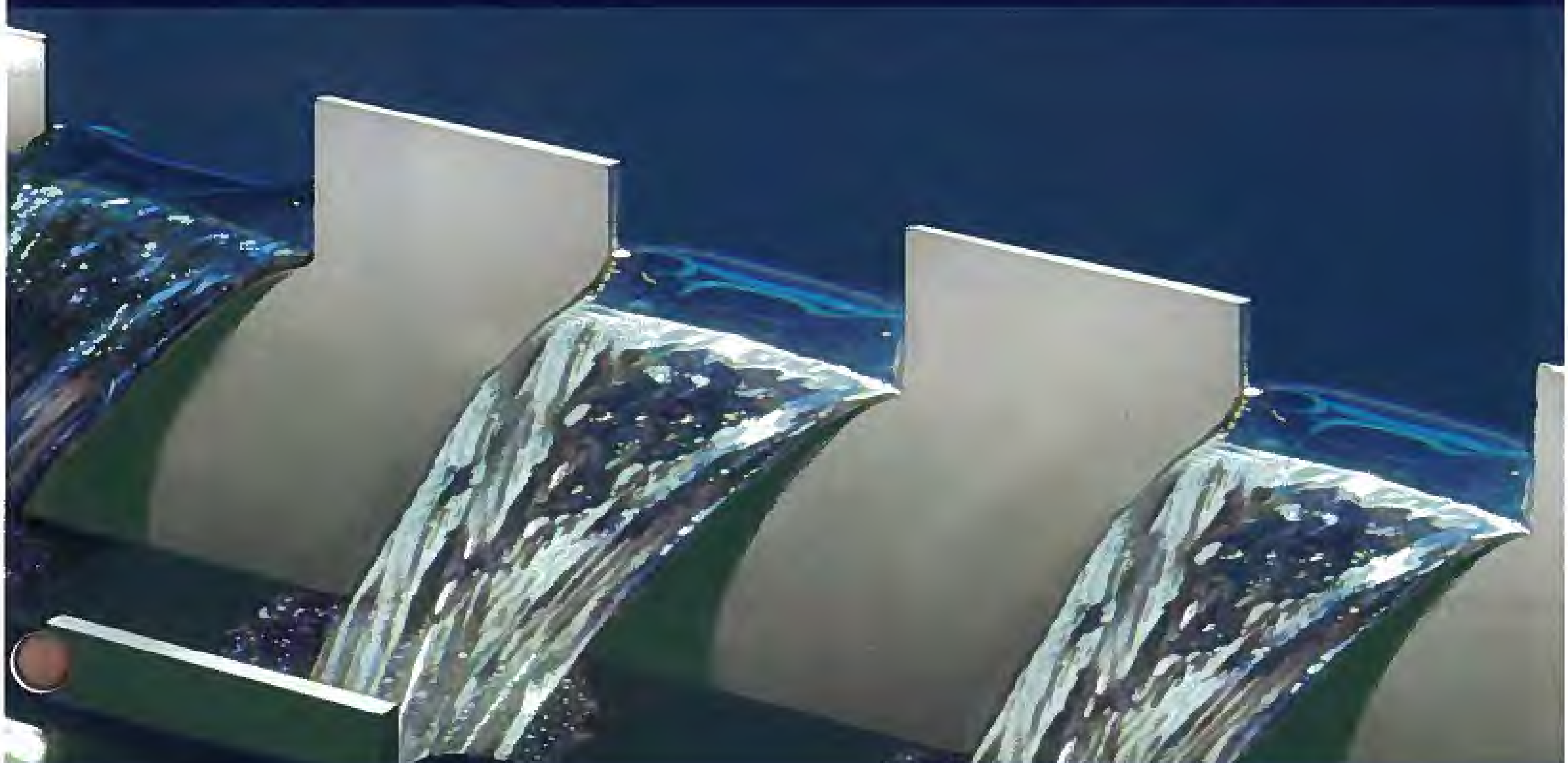
Koester Associates, Inc.

Dave, I hope this is helpful and sufficient for you to finalize your report. I am copying both Matt Cotton and Mike Gutshall at Kruger with this letter, so they will have a copy. If you have questions or need any additional information after receiving this, please feel free to either give me a call on my cell at 315-727-0836 or Matt or Mike directly.

Thank you,

Mark Koester

I:\Mark's Projects\Buffalo\McMin\Dave Miller Fax 1-30-04.doc



USFilter

ACTIFLO®
MICROSAND
BALLASTED
CLARIFICATION
PROCESS

Delta Diablo Sanitation District

THE MOST ADVANCED CLARIFICATION PROCESS

Relative footprint of the ACTIFLO process compared to conventional clarification.

- High quality effluent
- Clarifier rise rates from 20 to 70 gpm/ft²
- Footprints 5 to 50 times smaller than conventional clarification facilities
- Steady-state operation within 15 to 30 minutes of startup

These are just some of the reasons water and wastewater plants across North America are turning to the ACTIFLO® microsand ballasted flocculating clarification process from USFilters' Kruger Products.

ACTIFLO is the most advanced clarification process on the market today. It is a combination of two proven principles of rapid settling:

- Microsand enhanced flocculation where the microsand serves as seed for floc formation
- Microsand enhanced settling

The microsand enhances flocculation and acts as a ballast, resulting in a unique floc with rapid settling characteristics. This permits clarifier designs with short retention times and high rise rates. As a result, ACTIFLO process footprints can be 5 to 50 times smaller than conventional clarification systems of similar capacity.

At the same time, the microsand enhances system stability, enabling the ACTIFLO process to produce consistently high quality water despite rapidly changing influent water conditions. Since the process reaches steady state operation in a matter of minutes after start up, it is ideally suited for both drinking water and wastewater treatment applications.

Hydrocyclone recycles cleaned sand to ACTIFLO process.

How the Process Works

In the ACTIFLO® microsand ballasted clarification process, the raw water to be treated enters the coagulation tank where chemicals destabilize suspended solids and colloidal matter. Next, in the injection tank, polymer and microsand are added to initiate floc formation. The water then passes to the maturation tank where gentle mixing provides ideal conditions for the formation of polymer bridges between the microsand and the destabilized suspended solids.

The fully formed ballasted flocs leave the maturation tank and enter the settling tank. Here the microsand ballasted floc settles rapidly. The clarified water flows upward through the inclined plate or tube settlers. Clarified water exits the ACTIFLO process through collection troughs or weirs for further treatment and discharge in the case of wastewater; or to filtration, disinfection, and distribution in the case of drinking water.

The sand-sludge slurry collects at the bottom of the settling tank, where it is collected and pumped to hydrocyclones for separation. The microsand is concentrated and discharged from the bottom of the hydrocyclone and re-injected into the ACTIFLO process. The lighter density sludge is discharged at the top of the hydrocyclone and sent to thickening or final disposal.

Why it Works so Well

The ACTIFLO process differs from conventional clarification in that microsand is used as a ballasting agent in the flocculation process step. The microsand plays several important roles:

- The large surface-area of the sand particles serves as a "seed" for floc formation.
- The microsand and polymer produce a large, stable floc.
- The microsand (specific gravity 2.65) serves as a ballast for the formation of high-density floc.
- The relatively high concentration of microsand in the mixing basin dampens the impact of sudden variations in the raw water quality.
- The chemically inert microsand does not react with the process chemistry, allowing it to be effectively removed from chemical sludge and reused in the process.
- The microsand ballasted flocs in the ACTIFLO process have considerably higher settling velocities than conventional flocs and allow clarifier rise rates up to 100 times higher than conventional treatment processes. These rates, coupled with space-saving inclined lamella settlers, translate directly into reduced system footprint, and significant reductions in total civil cost.

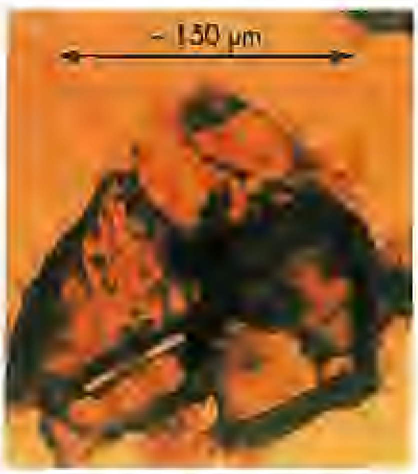


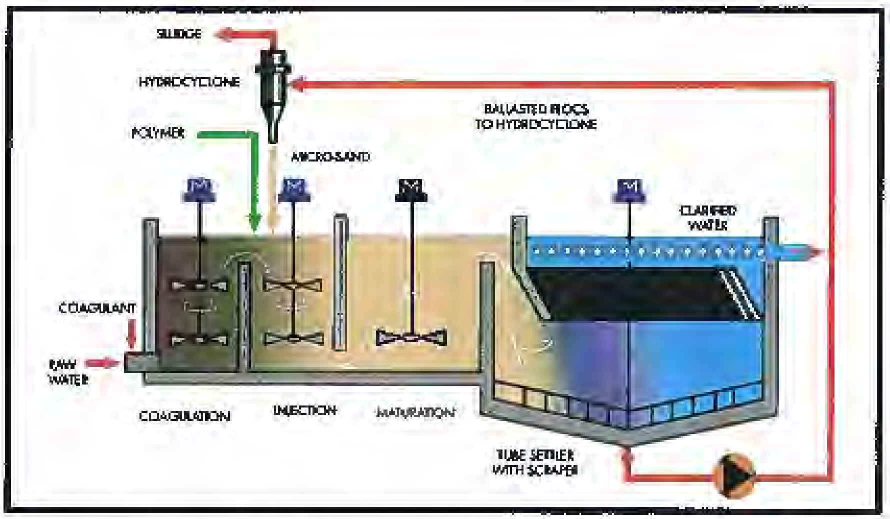
Photo micrograph of microsand ballasted floc.

APPLICATIONS

Today, the ACTIFLO® ballasted clarification process is applied successfully for many applications:

- Drinking water clarification
- Wastewater treatment
- Combined Sewer Overflows (CSO) and Sanitary Sewer Overflows (SSO)
- Tertiary treatment including phosphorus removal
- Filter backwash water treatment
- Industrial water and wastewater treatment

DESIGN CRITERIA FOR DRINKING WATER TREATMENT	
Microsand:	~ 100 µm
Nominal Rise Rate	20 – 30 gpm/ft²
Coagulation/ Flocculation Retention Time:	10 – 12 minutes
Maximum Single Train Capacity:	30 – 35 MGD
Maximum Multiple Train Capacity:	Unlimited
Minimum Single Train Capacity:	0.20 MGD



For treating ground water or surface water, the ACTIFLO® microsand ballasted clarification process can be applied wherever physical-chemical treatment including coagulation, flocculation and settling is used. The ACTIFLO process consistently delivers high quality effluent from raw waters containing both high and low turbidity, TOC, algae, particle counts, cryptosporidium, giardia, iron, manganese, arsenic and other typical water contaminants.

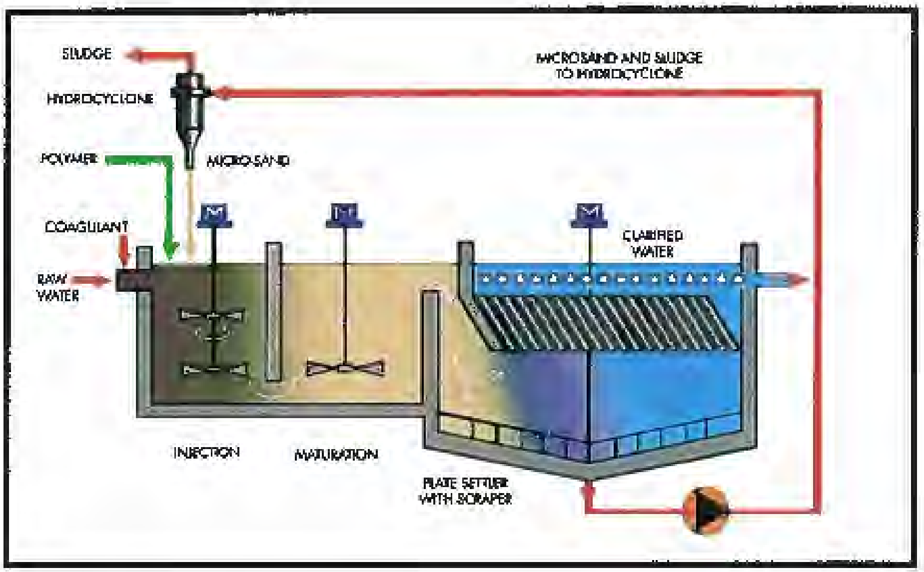
In the ACTIFLO process, the combination of efficient mixing and microsand ballasted flocculation ensures high quality clarified water when treating raw water with the following conditions:

- Low temperature
- High turbidity water up to several thousand NTU
- Low turbidity
- TOC (essential for prevention of disinfection byproducts)
- Iron and manganese (from surface or ground water sources)
- Color as high as 500 PCU
- Algae
- Cryptosporidium and Giardia

TYPICAL DRINKING WATER CONTAMINANT REMOVAL EFFICIENCIES

Parameter	Settled Water	Filtered Water
Turbidity, NTU	0.20 – 2.0 NTU	< 0.10 NTU
Color, PCU	0 – 10 PCU	0 – 5 PCU
TOC Removal	25 – 80%	25 – 85%
Algae Removal	90 – 99%	> 95%
Particle Counts, 2 – 15µ	1.0 – 2.5 log removal	> 3.0 log removal
Metals (Iron, Manganese, Arsenic)	80 – 99%	> 95%
Cryptosporidium and Giardia*	Not Detectable	Not Detectable

*Raw water with 20 counts/100L

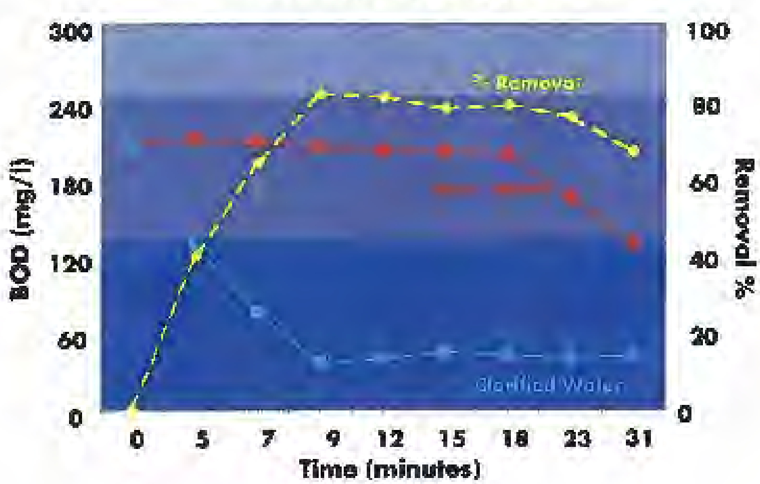


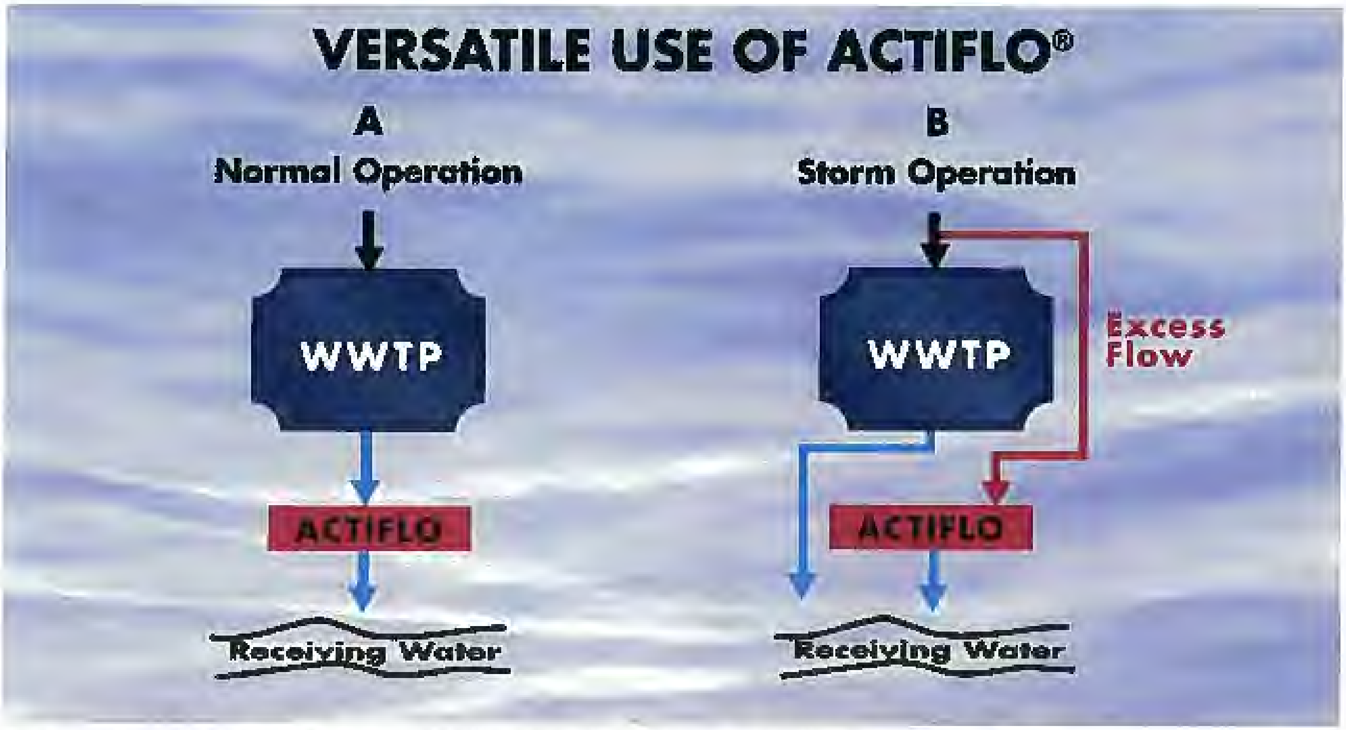
Municipalities of all sizes can use the ACTIFLO® microsand ballasted clarification process to improve performance and/or reduce costs for primary and tertiary wastewater treatment. The ACTIFLO process can be applied whenever physical-chemical treatment including coagulation, flocculation and settling is used. The ACTIFLO process is ideal for storm water treatment including CSO's, SSO's, and other wet weather flows, due to its high performance, small footprint and extremely quick start up time. The ACTIFLO process consistently delivers efficient removal of TSS, BOD, Phosphorous, COD, metals, fecal coliform, and other wastewater contaminants.

DESIGN CRITERIA WASTEWATER	
Microsand:	~150 µm
Nominal Overflow Rate:	50–70 gpm/ft²
Coagulation/ Flocculation Retention Time:	3–5 minutes
Maximum Single Train Capacity:	100 MGD
Maximum Multiple Train Capacity:	Unlimited
Minimum Single Train Capacity:	0.35 MGD

ACTIFLO startup BOD removal performance in wet weather treatment

Overflow rate = 40 gpm/sf





The versatility of the ACTIFLO® microsand ballasted clarification process allows for the treatment of secondary wastewater plant effluent as shown in "A". It can also treat excess wet weather flows during storm events as shown in "B".
The rapid startup of the process is an important factor in CSO/SSO treatment. Stable steady-state operation can be achieved in as little as 10-15 minutes.

CSO & SSO TREATMENT

Acheres, Paris, France

Communities with combined sanitary and storm sewer systems must reduce the impact of CSO and SSO events on the environment. The ACTIFLO process provides rapid treatment of wet weather flows as they occur. Thereby eliminating the need for constructing large retention basins. This high rate treatment process translates directly into reduced system footprint and significant reductions in total civil costs.

TYPICAL CONTAMINANT REMOVAL EFFICIENCIES	
TSS	90 – 95%
BOD (Total)	50 – 80%
Total P	85 – 95%
COD	50 – 80%
Metals	50 – 90%
Fecal Coliform	> 95%
TKN	10 – 40%

ACTIFLO process pilot demonstration unit.

Comparison with conventional water clarification

Pilot Study	Influent Turbidity (NTU)	Coagulant	Existing Conventional Full-Scale Plant		ACTIFLO Mobile Demo Unit	
			Dosage (mg/l)	Clarifier Turbidity (NTU)	Dosage (mg/l)	Clarifier Turbidity (NTU)
PA	10 – 15	Alum	40 – 50	1.5 – 2	20 – 30	0.3 – 0.5
GA	5 – 10	Alum	6 – 7	1 – 2	5 – 6	0.4 – 0.5
VA	10 – 15	Alum	55 – 60	0.5 – 1.2	20 – 30	0.3 – 0.4
CO	1 – 5	Alum	20	5 – 6	15 – 20	0.2 – 0.4
KY	50 – 90	Ferric Sulfate	10 – 15	3 – 5	10 – 15	0.6 – 0.7
MD	0.8 – 1.2	Alum	10 – 12	0.5 – 0.7	6 – 8	0.2 – 0.3

You can field-test the ACTIFLO® microsand ballasted clarification process at your site with one of USFilter's Kruger Products trailer-mounted pilot units. Each trailer contains all necessary ACTIFLO process equipment, chemical feed systems, controls, and laboratory equipment—forming a self-contained on site treatment process capable of demonstrating the performance of the ACTIFLO process across a wide range of operating conditions. Our pilot test engineers can set up and have a pilot system operational within 1-2 days. Typical test periods last from 2-3 weeks.

FAST FACTS:

- **The ACTIFLO process was introduced to the U.S. market in the early 1990s.**
- **Total retention time in an ACTIFLO process is less than 15 minutes.**
- **In CSO/SSO applications, overflow rates can be in excess of 60 gpm/ft², based on water surface area.**
- **The ACTIFLO process can effectively treat flows between 15 and 150 percent of nominal design capacity.**
- **In drinking water applications, settled water turbidites are typically less than 1.0 NTU.**
- **In wastewater applications, the ACTIFLO process typically removes 95 percent TSS, 50 – 80 percent reduction in BOD.**
- **The ACTIFLO process can remove phosphorus up to 95% of influent levels.**
- **Clarifier overflow rates are 10 times higher than those in lamella separators, up to 100 times those in conventional clarifiers.**
- **Microsand and sludge separate easily in a hydrocyclone.**
- **System sand losses are minimal.**
- **Sludge from the ACTIFLO process decants readily, thickens and dewaters easily.**

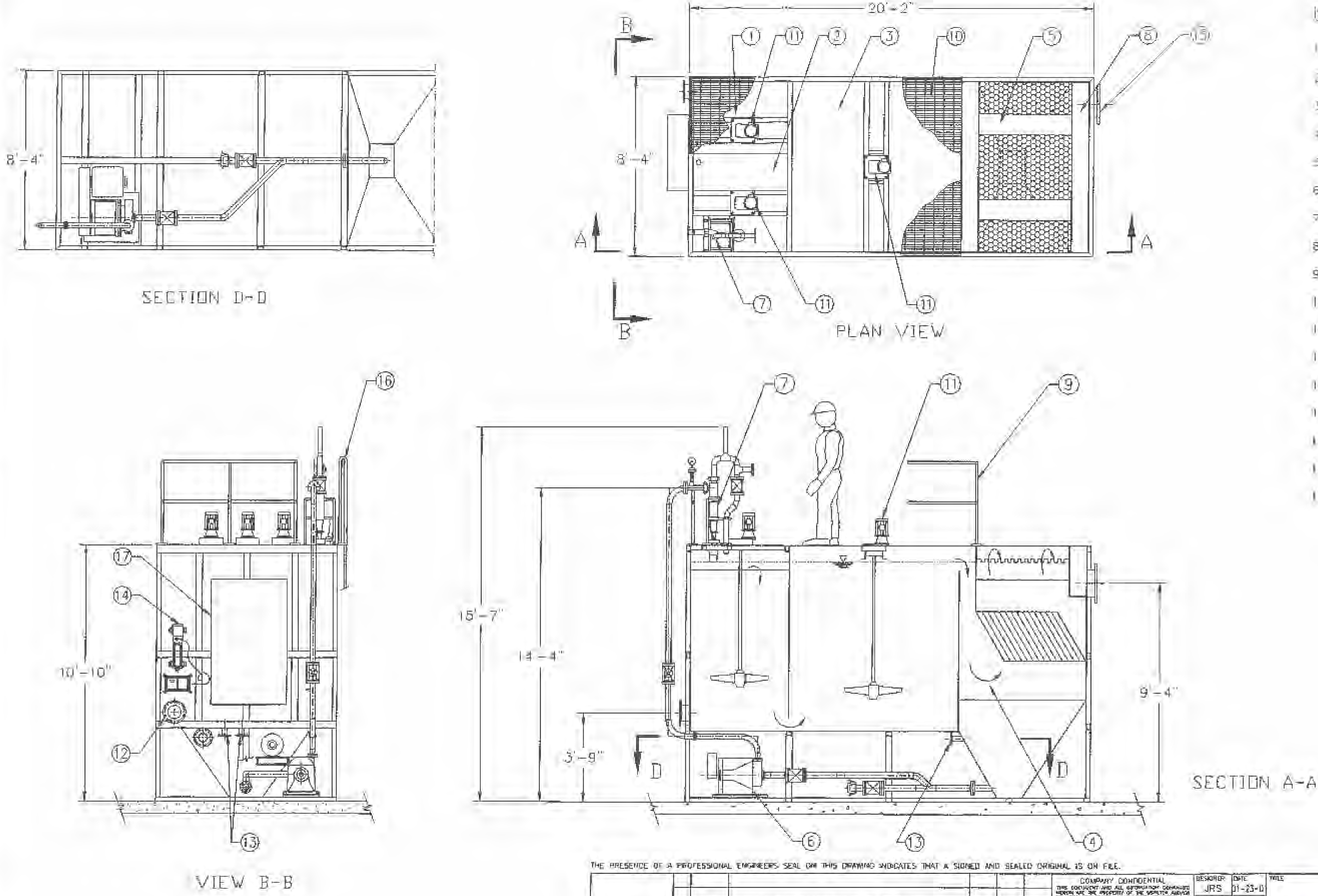
Bremerton, WA 1 × 10 MGD ACTIFLO Process Train for Wet Weather Treatment

For performance information on specific installations, or to ask for a pilot test of the ACTIFLO® microsand ballasted clarification process on your application, contact us at:

USFilter

Kruger Products
401 Harrison Oaks Blvd., Suite 100
Cary, NC 27513
919.677.8310 *phone*
919.677.0082 *fax*
www.usfilter.com

VIVENDI
Environnement company



NOTES:

1. COAGULATION TANK
2. INJECTION TANK
3. MATURATION TANK
4. SETTLING TANK
5. SETTLED WATER TROUGH
6. MICROSAND RECIRCULATION PUMP
7. HYDROCYCLONE
8. SETTLED WATER INLET
9. HANDRAIL
10. GRATING
11. MIXER
12. RAW WATER
13. DRAIN
14. TURBIDIMETER
15. SETTLED WATER OUTLET
16. LADDER
17. CONTROL PANEL

ONLY (1) TRAIN SHOWN

THE PRESENCE OF A PROFESSIONAL ENGINEERS SEAL ON THIS DRAWING INDICATES THAT A SIGNED AND SEALED ORIGINAL IS ON FILE.

rev	date	description	dwn	chk	appv
2	04-02-02	UPDATED DIM BASED ON JMI 10-31-02 BINDER	CMD	..	CMD
1	06-04-01	ADDED COAGULATION MIXER	JWW		CMD
0	01-23-01	REDRAWN - INITIAL RELEASE	JRS	JWW	VGS

GRAPHICAL SCALE 0 0.5 1 2 3 6

COMPANY CONFIDENTIAL

DESIGNER JRS	DATE 01-23-01	
CHECKER JWW	DATE	
ENGINEER CMD	DATE	
MANAGER VGS	DATE	
FILE		
SCALE NTS		

TITLE: STANDARD DESIGN ACTIFLO PACKAGE PLANT - ACP 400

CLIENT: STANDARDS AND PROCEDURES

USFilter — KRUGER PRODUCTS, 401 HARRISON OAKS BLVD CARY, NC 27513, (919) 677-8310 FAX (919) 677-0082

CLASSIFICATION	PROJECT No.	DRAWING	SHEET	REV
	660000	650PK-ACP-4001	1 OF 1	2

INTERNAL REF NO:

IF BAR IS NOT 1", ADJUST SCALE ACCORDINGLY

Buffalo Sewer Authority - LTCP

Conceptual Cost Estimate For Alternative 3 Pipelines

12/11/2003

Depth of Excavation	Pipe Diameter						
	24"	36"	48"	60"	72"	84"	96"
0-10' Excavation	$94	$115	$142	$305	$375	$435	$565
10'-20' Excavation	$121	$142	$169	$382	$452	$512	$642
20'-30' Excavation	$171	$192	$219	$475	$545	$605	$735

Notes:
Prices are in Cost Per Linear Foot of Installed Pipe
All Pipe is Reinforced Class 3 Concrete Sewer Pipe
Refer to "Reinforced Concrete Sanitary Sewer Pipe Costs" Prepared on 12/11/**03** for Backup

MALCOLM PIRNIE

CALCULATION COVER SHEET

Client: Buffalo Sewer Authority Project No.: **1777-095**

Project Name: LTCP Alternative Analysis

Project Description: Prepare a conceptual cost estimate to provide and install various sewer pipe sizes at three different depths (0-10 feet, 10-20 feet, 20-30 feet) in the City of Buffalo

Total Number of Pages (including cover sheet): 7

Total Number of Computer Runs: N/A

Prepared by: Ben Girard Date: 12/11/03

Checked by: Date:

Description and Purpose:

1. One Alternative in the Buffalo Sewer Authority's LTCP includes diverting water from various combined sewer overflows in the City of Buffalo, to a proposed tunnel system which would be located approximately 80 feet below grade. Various pipe sizes and depths will be required to transport water from the CSO to tunnel shafts. This conceptual cost estimate prices out seven different pipe diameters at three depths below grade: (0-10 feet, 10-20 feet, 20-30 feet).

Assumptions:

1. The pipe material used for this estimate was Class 3 Reinforced Concrete
2. The average pipeline length between mobilizations is approximately 1,500 liner feet
3. All excavated material will be temporarily stockpiled near the excavation, and backfilled in into the trench once the pipe is installed. Any additional material will be spread in the immediate area. Select fill will be used to bed and cover the pipe only.
4. Stacked trench shields will be used for the 20 and 30-foot excavation. Since stacking three trench shields is not practical, contractor will double stack the shields and use an open cut for the top 10 feet of a 30-foot excavation.
5. All work will be in the City of Buffalo
6. Dewatering is assumed to be necessary for approximately 50% of the time.
7. The pipe installation crew and equipment will consist of 1 excavator, 1 loader, 1 supervisor, 2 laborers, and 2 operators

Remarks/Conclusions/Results:

- See attached excel spreadsheet and backup data for tabulation of pipe costs. There has been no contingency percentage applied to the costs.

Calculation Approved by: ______________________

Project Manager/Date

Reinforced Concrete Sanitary Sewer Pipe Costs

① Contractor & Supplier Data:

- Pipe Material (Class 3 Reinforced Concrete)

24" Pipe - $21/ft

36" Pipe - $42/ft

48" Pipe - $69/ft

60" Pipe - $115/ft

72" Pipe - $185/ft

84" Pipe - $245/ft

96" Pipe - $375/ft

* Prices supplied by Dave Gangloff of K&S Contractor's Supply on 12/11/03 Ph# (716) 759-6911

Includes delivery to City of Buffalo locations

- Installation Costs

- Since groundwater conditions vary throughout the City, and three potential pipe depth ranges are realized (0-10', 10'-20', 20'-30'), potential dewatering will take place sporadically. The average pipeline length from CSO to tunnel shaft is estimated at 1,500 LF. John Kuhn of SLC Environmental Services said to figure about $1,000/day water is encountered without knowing conditions and flow rates. We will assume water is encountered for 50% of installation time. Assume 15 days for 1,500 ft run → $7,000/run ≈ $5/LF

The following Install & pricing information was provided by John Kuhn, Vice President of SLC Environmental Services: (716)-433-0776 ext 20

For 24", 36", and 48" Pipes, figure:

0-10' - $20/LF for excavation / backfill
10'-20' - $40/LF for " "
20'-30' - $60/LF for " "

* This assumes approx 54" wide Trench Shields
* All excavated Material will be backfilled after pipe installation
*

Production Rates:

0-10' - approx 200'/day
10'-20' - approx 150'/day
20'-30' - approx 75'/day

Daily Costs for Pipe installation:

1 excavator, 1 loader, 2 operators, 1 Supervisor, 2 laborers, misc

$4,500/day
↓

0-10' - 200'/day ÷ $4500 = $22.5/LF for labor, equip & misc

10'-20' - 150'/day ÷ 4500 = $30/LF for labor, equip, misc.

MALCOLM PIRNIE

MALCOLM PIRNIE, INC.

BY BG DATE 12/11/03 SHEET NO. 3 OF 6

CHKD. BY .... DATE .... JOB NO. ....

SUBJECT ....

20'-30' - 75'/day ÷ $4,500 = $60/LF for labor, equip, misc

Select Fill: approx 1 CY per foot at $25/CY (Pipe Bedding)

For 60", 72", 84", and 96" pipes, figure:

6-10' - $60/LF for excavation/backfill

10'-20' - $120/LF for " "

20'-30' - $180/LF for " "

* This assumes a 10' wide trench box
* All excavated material will be stockpiled near trench and used for backfill

Production Rates:

6-10' - approx 100'/day

10'-20' - approx ~~150~~ 75'/day

20'-30' - approx 50'/day

Daily Costs for installation;

Same as other with an additional $500/day for larger excavator → $ 5,000 / day

↓

0-10' - 100'/day → $5000/day = $50/LF for labor, equip, misc

10'-20' - 75'/day → $5,000 $ 67/LF " " "

20'-30' - 50'/day → $5,000 $ 100/LF " " "

Select Fill;

approx 3 CY per foot at $25/CY

so $75/LF

Summary

See Chart on Page 5

☆ These Costs assume an average of 1,500 feet per each pipeline (CSO to Shaft)

MALCOLM PIRNIE

MALCOLM PIRNIE, INC.

BY BG DATE 6/11 SHEET NO. 5 OF 6

CHKD. BY .... DATE .... JOB NO. ....

Contractor & Supplier Cost Data Summary / SUBJECT

* all costs/LF

Size/Depth	Material Cost & Delivery	Dewatering	Excavation & General Backfill	Pipe Install	Select Fill	Total/LF
24" / 0-10'	$21	$5	$20	$23	$25	$94
24" / 10'-20'	$21	"	$40	$30	"	$121
24" / 20'-30'	$21	"	$60	$60	"	$171
36" / 0'-10'	$42	"	$20	$23	"	$115
36" / 10'-20'	$42	"	$40	$30	"	$142
36' / 20'-30'	$42	"	$60	$60	"	$192
48" / 0'-10'	$69	"	$20	$23	"	$142
48" / 10'-20'	$69	"	$40	$30	"	$169
48' / 20'-30'	$69	"	$60	$60	"	$219
60" / 0-10'	$115	"	$60	$50	$75	$305
60" / 10'-20'	$115	"	$120	$67	"	$382
60" / 20'-30'	$115	"	$180	$100	"	$475
72" / 0-10'	$185	"	$60	$50	"	$375
72" / 10'-20'	$185	"	$120	$67	"	$452
72" / 20'-30'	$185	"	$180	$100	"	$545
84" / 0-10"	$245	"	$60	$50	"	$435
84" / 10'-20'	$245	"	$120	$67	"	$512
84" / 20'-30'	$245	"	$180	$100	"	$605
96" / 0-10'	$375	"	$60	$50	"	$565
96" / 10'-20'	$375	"	$120	$67	"	$642
96" / 20'-30'	$375	"	$180	$100	"	$735

Rock Excavation:

Don Braasch of Braasch Construction: (627-3811)

Cannot practically dig or demolish solid limestone; must be blasted. He has received recent bids for quantities > 100 CY around \$20/CY. We will assume \$30/CY to blast (possibly smaller quantities) and \$20/CY to dig and haul off-site

Total - \$50/CY

John Kuhn - SLC

Top 2' of rock ≃ \$40/CY to rip

again, anything > 2', need to blast

Tony Merk - Merk Drilling & Blasting - \$80/CY for trench rock blasting (includes drilling, blasting, survey, etc.)

See Attached Supplemental Means Info & Excel Summary

02520 | Wells

		02520 Wells	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2003 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
900	8220	20" diameter	B-23A	31.20	.769	L.F.	276	21.50	75.50	373	420	900
	8230	24" diameter		23.80	1.008		340	28	99.50	467.50	530	
	8240	26" diameter		21	1.143		375	32	113	520	590	
	8300	Slotted PVC, 1-1/4" diameter		521	.046		1.38	1.29	4.54	7.21	8.50	
	8310	1-1/2" diameter		488	.049		2.01	1.38	4.84	8.23	9.70	
	8320	2" diameter		273	.088		2.79	2.46	8.65	13.90	16.35	
	8330	3" diameter		253	.095		2.96	2.65	9.35	14.96	17.60	
	8340	4" diameter		200	.120		3.41	3.36	11.80	18.57	22	
	8350	5" diameter		168	.143		3.58	4	14.05	21.63	25.50	
	8360	6" diameter		126	.190		4.97	5.35	18.75	29.07	34	
	8370	8" diameter		98.50	.244		7.50	6.80	24	38.30	45.50	
	8400	Artificial gravel pack, 2" screen, 6" casing	B-23B	174	.138		2.01	3.86	14.85	20.72	24.50	
	8405	8" casing		111	.216		2.74	6.05	23.50	32.29	38	
	8410	10" casing		74.50	.322		3.44	9	34.50	46.94	55.50	
	8415	12" casing		60	.400		4.65	11.20	43	58.85	70	
	8420	14" casing		50.20	.478		6	13.35	51.50	70.85	83.50	
	8425	16" casing		40.70	.590		8.30	16.50	63.50	88.30	105	
	8430	18" casing		36	.667		9.65	18.65	72	100.30	119	
	8435	20" casing		29.50	.814		11.10	23	87.50	121.60	144	
	8440	24" casing		25.70	.934		12.30	26	101	139.30	165	
	8445	26" casing		24.60	.976		13.75	27.50	105	146.25	173	
	8450	30" casing		20	1.200		15.80	33.50	129	178.30	211	
	8455	36" casing		16.40	1.463		17	41	158	216	256	
	8500	Develop well		8	3	Hr.	180	84	325	589	685	
	8550	Pump test well		8	3		48	84	325	457	540	
	8560	Standby well	B-23A	8	3		46.50	84	295	425.50	505	
	8570	Standby, drill rig		8	3			84	295	379	455	
	8580	Surface seal well, concrete filled		1	24	Ea.	440	670	2,375	3,485	4,100	
	8590	Well test pump, install & remove	B-23	1	40			1,000	2,425	3,425	4,250	
	8600	Well sterilization, chlorine	2 Clab	1	16		380	395		775	1,025	
	9950	See div. 02240-900 for wellpoints										
	9960	See div. 02240-700 for drainage wells										
910	0010	**PUMPS, WELL** Water system, with pressure control										910
	1000	Deep well, jet, 42 gal. galvanized tank										
	1040	3/4 HP	1 Plum	.80	10	Ea.	570	375		945	1,200	
	3000	Shallow well, jet, 30 gal. galvanized tank										
	3040	1/2 HP	1 Plum	2	4	Ea.	360	149		509	620	

02530 | Sanitary Sewerage

		02530 Sanitary Sewerage	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
730	0010	**PIPING, DRAINAGE & SEWAGE, CONCRETE**										730
	0020	Not including excavation or backfill										
	1000	Non-reinforced pipe, extra strength, B&S or T&G joints										
	1010	6" diameter	B-14	265.04	.181	L.F.	3.93	4.72	.83	9.48	12.60	
	1020	8" diameter		224	.214		4.32	5.60	.98	10.90	14.50	
	1030	10" diameter		216	.222		4.79	5.80	1.01	11.60	15.35	
	1040	12" diameter		200	.240		5.90	6.25	1.09	13.24	17.40	
	1050	15" diameter		180	.267		6.90	6.95	1.22	15.07	19.70	
	1060	18" diameter		144	.333		8.45	8.70	1.52	18.67	24.50	
	1070	21" diameter		112	.429		10.40	11.15	1.95	23.50	31	
	1080	24" diameter		100	.480		12.75	12.50	2.19	27.44	36	
	2000	Reinforced culvert, class 3, no gaskets										
	2010	12" diameter	B-14	210	.229	L.F.	9.80	5.95	1.04	16.79	21	
	2020	15" diameter		175	.274		12.55	7.15	1.25	20.95	26.50	
	2030	18" diameter		130	.369		13.20	9.60	1.68	24.48	31.50	
	2035	21" diameter		120	.400		17.15	10.40	1.82	29.37	37	

		02530 | Sanitary Sewerage	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2003 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
730	2040	24" diameter	B-14	100	.480	L.F.	19.45	12.50	2.19	34.14	43.50
	2045	27" diameter	B-13	92	.609		24.50	16.30	7.10	47.90	60
	2050	30" diameter		88	.636		26.50	17	7.45	50.95	64
	2060	36" diameter		72	.778		38	21	9.10	68.10	84
	2070	42" diameter	B-13B	72	.778		52	21	16.05	89.05	107
	2080	48" diameter		64	.875		64.50	23.50	18.05	106.05	127
	2090	60" diameter		48	1.167		103	31	24	158	188
	2100	72" diameter		40	1.400		145	37.50	29	211.50	250
	2120	84" diameter		32	1.750		246	47	36	329	380
	2140	96" diameter		24	2.333		295	62.50	48	405.50	475
	2200	With gaskets, class 3, 12" diameter	B-21	168	.167		11.75	4.78	.97	17.50	21.50
	2220	15" diameter		160	.175		14.10	5	1.02	20.12	24.50
	2230	18" diameter		152	.184		17.65	5.30	1.07	24.02	29
	2240	24" diameter		136	.206		26.50	5.90	1.20	33.60	39.50
	2260	30" diameter	B-13	88	.636		35.50	17	7.45	59.95	73.50
	2270	36" diameter	"	72	.778		53	21	9.10	83.10	101
	2290	48" diameter	B-13B	64	.875		86.50	23.50	18.05	128.05	151
	2310	72" diameter	"	40	1.400		224	37.50	29	290.50	335
	2330	Flared ends, 6'-1" long, 12" diameter	B-21	190	.147		32.50	4.23	.86	37.59	43.50
	2340	15" diameter		155	.181		38	5.20	1.05	44.25	50.50
	2400	6'-2" long, 18" diameter		122	.230		39.50	6.60	1.34	47.44	55
	2420	24" diameter		88	.318		45.50	9.15	1.86	56.51	66
	2440	36" diameter	B-13	60	.933		82.50	25	10.90	118.40	142
	3040	Vitrified plate lined, add to above, 30" to 36" diameter				SFCA	3.40			3.40	3.74
	3050	42" to 54" diameter, add					3.64			3.64	4
	3060	60" to 72" diameter, add					4.26			4.26	4.69
	3070	Over 72" diameter, add					4.54			4.54	4.99
	3080	Radius pipe, add to pipe prices, 12" to 60" diameter				L.F.	50%				
	3090	Over 60" diameter, add				"	20%				
	3500	Reinforced elliptical, 8' lengths, C507 class 3									
	3520	14" x 23" inside, round equivalent 18" diameter	B-21	82	.341	L.F.	22	9.80	1.99	33.79	41.50
	3530	24" x 38" inside, round equivalent 30" diameter	B-13	58	.966		39	26	11.30	76.30	95.50
	3540	29" x 45" inside, round equivalent 36" diameter		52	1.077		49.50	29	12.60	91.10	113
	3550	38" x 60" inside, round equivalent 48" diameter		38	1.474		76	39.50	17.25	132.75	163
	3560	48" x 76" inside, round equivalent 60" diameter		26	2.154		116	57.50	25	198.50	245
	3570	58" x 91" inside, round equivalent 72" diameter		22	2.545		166	68	30	264	320
	3780	Concrete slotted pipe, class 4 mortar joint									
	3800	12" diameter	B-21	168	.167	L.F.	12.50	4.78	.97	18.25	22.50
	3840	18" diameter	"	152	.184	"	19.35	5.30	1.07	25.72	31
	3900	Class 4 O-ring									
	3940	12" diameter	B-21	168	.167	L.F.	13.20	4.78	.97	18.95	23
	3960	18" diameter	"	152	.184	"	17.70	5.30	1.07	24.07	29
780	0010	**PIPING, DRAINAGE & SEWAGE, POLYVINYL CHLORIDE**									
	0020	Not including excavation or backfill									
	2000	10' lengths, S.D.R. 35, B&S, 4" diameter	B-20	375	.064	L.F.	1.55	1.78		3.33	4.50
	2040	6" diameter		350	.069		2.61	1.91		4.52	5.85
	2080	8" diameter		335	.072		4.40	2		6.40	7.95
	2120	10" diameter	B-21	330	.085		6.65	2.43	.49	9.57	11.65
	2160	12" diameter		320	.087		7.40	2.51	.51	10.42	12.60
	2200	15" diameter		190	.147		11.15	4.23	.86	16.24	19.80
790	0010	**PIPING, DRAINAGE & SEWAGE, VITRIFIED CLAY** C700									
	0020	Not including excavation or backfill,									
	4030	Extra strength, compression joints, C425									
	5000	4" diameter x 4' long	B-20	265	.091	L.F.	1.66	2.52		4.18	5.75
	5020	6" diameter x 5' long	"	200	.120		2.78	3.34		6.12	8.30
	5040	8" diameter x 5' long	B-21	200	.140		3.96	4.02	.82	8.80	11.50

02240 | Dewatering			CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2003 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
500	1000	4" diaphragm pump	B-10I	1	12	Day		360	107	467	665
	1100	6" centrifugal pump	B-10K	1	12			360	271	631	850
	1300	CMP, incl. excavation 3' deep, 12" diameter	B-6	115	.209	L.F.	7.45	5.60	1.90	14.95	18.90
	1400	18" diameter		100	.240	"	9.25	6.45	2.19	17.89	22.50
	1600	Sump hole construction, incl. excavation and gravel, pit		1,250	.019	C.F.	.68	.51	.18	1.37	1.73
	1700	With 12" gravel collar, 12" pipe, corrugated, 16 ga.		70	.343	L.F.	12.35	9.20	3.13	24.68	31
	1800	15" pipe, corrugated, 16 ga.		55	.436		15.75	11.70	3.98	31.43	40
	1900	18" pipe, corrugated, 16 ga.		50	.480		18.50	12.85	4.38	35.73	45
	2000	24" pipe, corrugated, 14 ga.		40	.600		22	16.10	5.45	43.55	55.50
	2200	Wood lining, up to 4' x 4', add		300	.080	SFCA	12.55	2.14	.73	15.42	17.90
	9950	See div. 02240-900 for wellpoints									
	9960	See div. 02240-700 for deep well systems									
700	0010	**WELLS** For dewatering 10' to 20' deep, 2' diameter									
	0020	with steel casing, minimum	B-6	165	.145	V.L.F.	2.30	3.90	1.33	7.53	10
	0050	Average		98	.245		4.59	6.55	2.23	13.37	17.65
	0100	Maximum		49	.490		12.25	13.15	4.47	29.87	39
	0300	For pumps for dewatering, see division 01590-400-4100 to 4400									
	0500	For domestic water wells, see division 02520-900									
900	0010	**WELLPOINTS** For wellpoint equipment rental, see div. 01590-700 R02240-900									
	0100	Installation and removal of single stage system									
	0110	Labor only, .75 labor-hours per L.F., minimum	1 Clab	10.70	.748	LF Hdr		18.45		18.45	29
	0200	2.0 labor-hours per L.F., maximum	"	4	2	"		49.50		49.50	77
	0400	Pump operation, 4 @ 6 hr. shifts									
	0410	Per 24 hour day	4 Eqlt	1.27	25.197	Day		785		785	1,175
	0500	Per 168 hour week, 160 hr. straight, 8 hr. double time		.18	177	Week		5,525		5,525	8,375
	0550	Per 4.3 week month		.04	800	Month		24,900		24,900	37,700
	0600	Complete installation, operation, equipment rental, fuel &									
	0610	removal of system with 2" wellpoints 5' O.C.									
	0700	100' long header, 6" diameter, first month	4 Eqlt	3.23	9.907	LF Hdr	122	310		432	600
	0800	Thereafter, per month		4.13	7.748		97.50	241		338.50	470
	1000	200' long header, 8" diameter, first month		6	5.333		108	166		274	370
	1100	Thereafter, per month		8.39	3.814		55	119		174	241
	1300	500' long header, 8" diameter, first month		10.63	3.010		42.50	93.50		136	189
	1400	Thereafter, per month		20.91	1.530		30.50	47.50		78	106
	1600	1,000' long header, 10" diameter, first month		11.62	2.754		36.50	85.50		122	171
	1700	Thereafter, per month		41.81	.765		18.30	24		42.30	56
	1900	Note: above figures include pumping 168 hrs. per week									
	1910	and include the pump operator and one stand-by pump.									

02250 | Shoring & Underpinning			CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
400	0010	**SHEET PILING** Steel, not incl. wales, 22 psf, 15' excav., left in place	B-40	10.81	5.920	Ton	800	187	216	1,203	1,425
	0100	Drive, extract & salvage		6	10.667		355	335	390	1,080	1,375
	0300	20' deep excavation, 27 psf, left in place R02250-450		12.95	4.942		800	156	180	1,136	1,325
	0400	Drive, extract & salvage		6.55	9.771		355	310	355	1,020	1,275
	1200	15' deep excavation, 22 psf, left in place		983	.065	S.F.	9.30	2.05	2.37	13.72	16.2
	1300	Drive, extract & salvage		545	.117		3.99	3.70	4.28	11.97	15.1
	1500	20' deep excavation, 27 psf, left in place		960	.067		11.70	2.10	2.43	16.23	18.9
	1600	Drive, extract & salvage		485	.132		5.20	4.16	4.81	14.17	17.7
	2100	Rent steel sheet piling and wales, first month				Ton	190			190	209
	2200	Per added month					19.05			19.05	21
	2300	Rental piling left in place, add to rental					635			635	700
	2500	Wales, connections & struts, 2/3 salvage					194			194	214
	3900	Wood, solid sheeting, incl. wales, braces and spacers,									
	3910	drive, extract & salvage, 8' deep excavation	B-31	330	.121	S.F.	1.67	3.20	.45	5.32	7.
	4000	10' deep, 50 S.F./hr. in & 150 S.F./hr. out		300	.133		1.72	3.52	.49	5.73	7.
	4100	12' deep, 45 S.F./hr. in & 135 S.F./hr. out		270	.148		1.77	3.92	.55	6.24	8.

BUFFALO SEWER AUTHORITY
Stage 3: System-Wide LTCP

Appendix 7-5 Separation Cost Information

EXAMPLE CALCULATION - PRELIMINARY STORM SEWER SEPARATION COST ESTIMATES DONE FOR VALPARAISO SUBBASINS

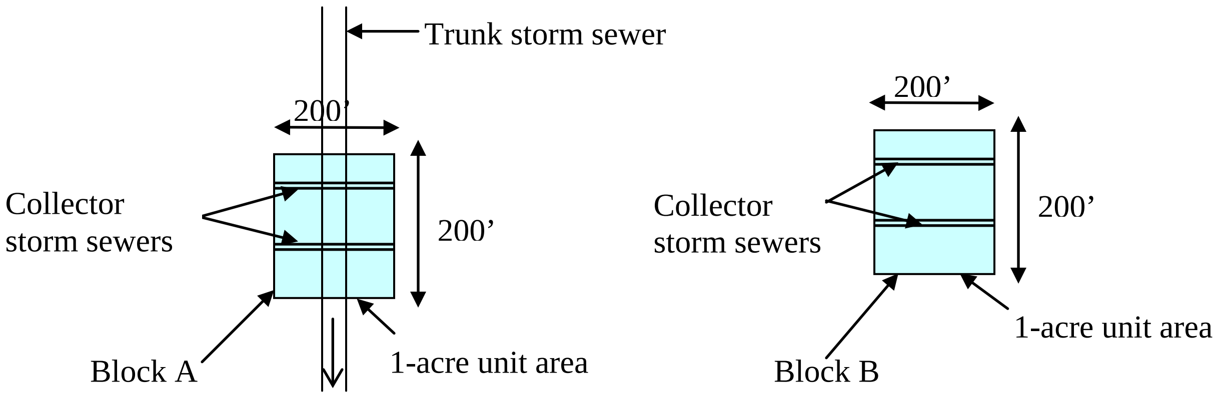
The average cost per acre to completely separate the sewers was estimated for each subbasin. It was assumed that each subbasin would have a main trunk storm sewer running at the center of the subbasin and collector storm sewers draining into it from the sides.

Figure 1 explains the concept behind the cost calculation. Two blocks – A and B, represent the storm sewer separation in the entire subbasin. Each block is 200 feet x 200 feet in size and has an area of approximately 1 acre.

Block A represents the interior parts of the subbasin. It would contain a main trunk storm sewer and two-collector storm sewers as its components. Cost C_1 would be the cost of storm sewer separation for block A. Cost C_1 consists of the cost of one main trunk storm sewer and two collector storm sewers and it will be representative of the cost/acre for storm sewer separation in the interior areas of the subbasin.

Block B represents the outer areas of the subbasin. It would contain only collector storm sewers (that would be conveying to the main trunk sewer, which runs through the center of the subbasin based on our assumption) as its components. Cost C_2 would be the cost of storm sewer separation for block B. Cost C_2 will only consist of the cost of two collector storm sewers and it will be representative of the cost/acre for the storm sewer separation in the outer areas of the subbasin.

The total average storm sewer separation cost/acre for the subbasin will be the weighted average of the costs C_1 and C_2. The weighted average takes into account the actual distribution percentages of block B (6 % of the subbasin area) and block A (94 % of the subbasin area) over the entire subbasin area. The following is a step-by-step procedure through which the cost/acre for storm sewer separation was calculated for each of these blocks.



Step 1: Determine Approximate Time of Concentration (T_c) for the Subbasin

A velocity of 2.5 fps was assumed. 7000' is the approximate drainage length for this subbasin.

T_c = 7000'/2.5 fps = 46.7 minutes

Step 2: Choose Design Storm for the Subbasin

A 10-year, 1-hour storm was chosen as the design storm; Intensity of 10-year, 1-hour storm (i) = 1.98 inches/hour.

Step 3: Determine the Average Runoff Coefficient (C) for the Subbasin

The average runoff coefficient for this area was calculated as C = 0.5.

Step 4: Calculate Runoff Discharge

Approximate area for the entire subbasin (A)

A = l x b = 3,500' x 7,000' / 43,560 = 562.4 acres

$Q_{max} = C \times i \times A = 0.5 \times 1.98 \times 562.4$

Q_{max} = 556 cfs (rounded to 560 cfs)

Step 5: Sizing and Cost for Trunk Storm Sewer

Sizing:

Assume that sewer is divided into 3 different size sections, the upstream section sized for carrying 187 cfs, middle section sized for carrying 374 cfs and the downstream section sized for carrying a maximum flow of 560 cfs. Find the diameter for the average flow (Q_{avg}) of 374 cfs and estimate the average cost of the sewer.

Using Manning's Equation:

$Q = 0.463 \times D^{8/3} \times S^{1/2} / n$

Where,

Q_{avg} = 374 cfs

Slope (S) = 70'/7000' = 0.01 (70' is the drop from the highest point to the end point of discharge. Sewer grade was assumed to follow ground elevation).

n = 0.013 (assumed)

Calculated diameter of trunk sewer = 5.73 ' ~ 72"

Cost:

Cost of 72" Diameter Pipe /LF = $ 350 /LF (From Previous Fort Wayne Projects)

Cost/acre = $ 400 /LF x 200 LF = $ 80,000.

Step 6: Sizing and Cost for Collector Storm Sewer

Sizing:

Area = 1,750' x 100' /43,560 = 4 acres.

$Q_{max} = C \times i \times A = 0.5 \times 1.98 \times 4 = 3.96$ cfs ~ 4 cfs.

This is the maximum discharge that the collector sewer will be handling. Assume that the entire sewer section is divided into 3 different size sections, the upstream section sized for carrying 1.33 cfs, middle section (Q_{avg}) sized for carrying 2.66 cfs and the downstream section sized for carrying a maximum flow of 4 cfs. Find the diameter for the average flow (Q_{avg}) of 2.66 cfs and estimate the average cost of the sewer.

Q_{avg} = 2.66 cfs; V = 2.5 cfs (assumed)

Using continuity equation, Area = Q/V

Calculated diameter of collector Sewer = 1.1’ ~ 15”

Average Cost:

Cost /LF for 15” sewer = $ 50. (From Previous Fort Wayne Projects)

Average Cost/acre =$ 50 /LF x 400 LF =$20,000

Step 7: **Estimate the Average Cost/Acre for Storm Sewer Separation in the Subbasin**

Cost/Acre for Block B (C_1).

- Cost of Trunk Sewer = $80,000
- Cost of Collector Sewers = $20,000
- Total Cost /Acre = $100,000

Cost/Acre for Block A (C_2)

- Cost of Collector Sewers = $20,000

Average Cost/Acre for entire subbasin (C)

- Average Cost / Acre = ($100,000 x 6 + $20,000 x 94) / 100

= $24,800

=$ 25,000 (rounded up cost)

Specific assumption for BSA:

$25,000 for partial separation
$50,000 for complete separation