Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

RESEARCH AND DEVELOPMENT DEPARTMENT

REPORT NO. 01-2

LITERATURE SEARCH OF POSSIBLE AERATION SYSTEMS AND WASHDOWN PROCEDURES FOR USE WITH THE PROPOSED McCOOK RESERVOIR

PART II

COMPARISON OF WASHDOWN PROCEDURES FOR DEEP RESERVOIRS AND RESERVOIRS WITH LARGE DEPTH VARIATIONS – A LITERATURE SEARCH AND REVIEW

February 2001

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By

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Prepared for the Metropolitan Water Reclamation District of Greater Chicago
as part of Army Corps of Engineers Contract
DACW23-97-D-0001
December 2000

Research and Development Department
Richard Lanyon, Director

February 2001

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ABSTRACT

This paper represents a search of the literature to compare various techniques (washing, vacuuming) to remove solids from the walls and floor of deep reservoirs used to temporarily store combined sewer overflows (CSOs). The storage reservoirs would be sited in the McCook Quarry or in similar quarries located in Cook County, Illinois. The following may be concluded from the literature search:

1. Manual cleaning has too many operating disadvantages and is too costly to be considered further.
2. Sweeper trucks are unlikely to be an effective method to remove liquid sludge from McCook Reservoir. The Material Service experience with this cleaning method is not relevant or practical for further consideration at the McCook Reservoir.
3. Flushing spray systems would appear to be a possible cleaning alternative for further consideration.
4. The use of a flushing wave system to remove sludge accumulations would appear to be a

possible cleaning alternative for further consideration.

5. Removal of sludge using front-end loaders or ploughing devices would appear to be a possible cleaning alternative for further consideration as it is currently being used at the O'Hare CUP Reservoir.

ACKNOWLEDGMENTS

The author would like to thank Dr. Jain S. Jain, Mr. Bernard Sawyer, Dr. Prakasam Tata, and Mr. Richard Lanyon of the Metropolitan Water Reclamation District of Greater Chicago, and Dr. David R. Zenz of CTE Engineers, Inc. for their thoughtful reviews and helpful suggestions in preparing the final version of this report.

The author would also like to thank Ms. Laura Franklin of the Metropolitan Water Reclamation District of Greater Chicago for assisting in the final typing of this report.

DISCLAIMER

The mention of proprietary equipment and chemicals in this report does not constitute endorsement by the author.

INTRODUCTION

The McCook Reservoir site is located on Metropolitan Water Reclamation District Of Greater Chicago (District) property in southwestern Cook County, Illinois. The McCook Reservoir, as proposed, will be a surface reservoir which will provide for storage of combined sewage overflows from the north, central and west portions of the District. This storage will reduce flood damage and minimize releases of untreated combined sewage to the waterways within and/or affected by the District. The Mainstream and Des Plaines tunnel systems were constructed and are operated by the District. These tunnels will transport combined sewage to the McCook Reservoir when flows exceed the pumping capacity of the Stickney Water Reclamation Plant (WRP). The McCook Reservoir, as proposed, will be composed of a 300 acre-feet (97.75 million gallons) sump, and two 10,700 acre-feet (3.49 billion gallons) stages for a total of 21,700 acre-feet (7.1 billion gallons). The proposed reservoir would be excavated in the bedrock immediately underlying the Chicago area.

The rock formation immediately underlying the Chicago region is primarily Silurian Dolomite, (dolomite = $CaMg(CO_3)_2$) part of a deposit greater than 400 million years old. The rock is part of the Niagaran series that extends under much of the midwest and northeast and is the same formation forming the lip of Niagara Falls in New York State and Canada (Bretz, 1939). The stone is more specifically part of the Racine (upper) formation of the Niagaran series (Willman, 1971). The dolomite is, in some areas, 500 feet thick (Willman, 1973).

Setting

The McCook Reservoir will be excavated in southwest Cook County in Silurian Dolomite for the purpose of storing combined sewer overflows (CSOs) as part of the Tunnel and Reservoir Plan (TARP). Nearby Du Page County is considering use of old quarries in Silurian Dolomite as temporary reservoirs for flood control (Charlton, 1994). TARP Phase I includes structures which will enhance water quality in the Chicago area and includes about 110 miles of tunnels, collector and drop shaft systems which connect local sewers to tunnels, and upgraded treatment works. Phase II involves the structures which are primarily involved with flood control and flood damage reduction (Price and Tillman, 1991). An earlier proposal (Buschbach and Helm, 1972) examined a proposal to tunnel through the Silurian Dolomite to formations as deep as 800 feet below surface levels. The current plan includes use of a reservoir for temporary storage for combined sewer and storm flow (Fletcher, 1991). A hydraulic analysis of the proposed McCook Outlet

Manifold was presented by Stockstill (1993). The storage system would be sufficient to capture the runoff from a 30-year, 24-hour runoff. The water surface elevation would always be below the surface elevation of the reservoir. The CUP McCook reservoir is expected to eliminate or severely restrict approximately 10-15 combined sewer overflow events per year. Water could be stored for as long as 70 days in the reservoir. A variety of research and design activities are being performed to support the aeration system design for the reservoir (Sorn, 1998).

CUP Reservoir System: Definition of the Washdown Problem

The reservoir would be drawn down slowly after partially filling during a storm event. During this drawdown period, some solid material present in the combined sewage/stormwater would adhere to the walls of the reservoir and possibly settle on the bottom of the reservoir.

Data from an O'Hare CUP Reservoir fill event in April 2000 indicated a mean depth of 0.72 inches of sludge produced during the 127 million gallon fill event. The reservoir was filled to a depth of 33.5 feet during the event. The O'Hare CUP Reservoir fill event took place on April 21-23, 2000, and sediment was measured after drawdown was completed on April

24, 2000. Total solids averaged 9.74 percent, and percent volatile solids averaged 52.3 percent.

The McCook Reservoir will in some ways be operated as an aerated lagoon which will provide enough oxygen to maintain a dissolved oxygen (DO) concentration of 2.0 mg/l. Thus, the reservoir should provide BOD_5 reduction and will function as a high performance aerated lagoon system (Rich, 1999). Following a filling event, the reservoir will gradually be drained over a one- to seventy-day period. Concerns of odor production require that the walls and floor of the reservoir be periodically cleaned in some manner. These odors would be caused by sulfur compounds such as hydrogen sulfide. While dolomite similar to that found in Chicago quarries is used for the removal of hydrogen sulfide, in certain industrial processes (Harvey et al., 1976) temperatures and pressures higher than ambient are used. Lime and dolomite have been traditionally used to control odors.

The sludge, if it becomes septic, could cause nuisance odors (hydrogen sulfide and other nuisance compounds) and could possibly be a breeding ground for insects. Hydrogen sulfide production and volatile organic compounds (VOCs) can cause serious problems at CSO holding facilities (Schoettle and Jamocian, 1997). Is there information in the literature which might lead to possible ways to remove this accumulated material from the walls and floor?

MATERIALS AND METHODS

Forty two databases were examined at the Galvin Library, Crerar Library, or on-line on the internet. One database, the Illinois State Geological Survey, was a hard copy. These databases are listed, along with key search words and completion dates, in Table 1 and Table 2 of Part I of this report. Additional searches were performed concerning reservoir washdown and are listed in Table 1 of this portion (Part II) of the report. Key words used in these searches are given in Table 2 of this portion (Part II) of the report. These additional searches yielded approximately 20 hits concerning reservoir washdown which were examined by title, and abstract, if available.

Those articles, books, or journal proceedings deemed relevant were obtained and copied. These were used for the comparison of washdown and cleaning of holding reservoirs and tanks that follows.

TABLE 1

DATABASES EXAMINED FOR WASHDOWN PROCEDURES

DATABASES EXAMINED AT ILLINOIS INSTITUTE OF TECHNOLOGY

Database	Description
Compendex Engineering	1970-1999

DATABASES EXAMINED BY CRERAR LIBRARY

Database	Description
BIOSIS	Previews 1969-present
NTIS	National Technical Information Service
Compendex	
Oceanic Abstracts	
Meteorological and Geophysical Abstracts	
SciSearch	Cited References 1990-present
ASFA	Aquatic Sciences and Fisheries
CAB	
GeoArchive	
Inside Conferences	
GeoRef	
JICST	Japanese Science and Technology

TABLE 1 (Continued)

DATABASES EXAMINED FOR WASHDOWN PROCEDURES

DATABASES EXAMINED BY CRERAR LIBRARY (Continued)

Database	Description
Fluidex	Fluid Engineering Abstracts
Wilson	Applied Science and Technology Abstracts
Water Resources Abstracts	
WATERNET	
GEOBASE	
SciSearch	Cited References Science database 1974-1989
Enviroline	1975-1999
Pollution Abstracts	1970-1999

TABLE 2

KEY WORDS USED TO SEARCH DATABASES FOR WASHDOWN PROCEDURES

KEY WORDS USED TO SEARCH DATABASE EXAMINED AT ILLINOIS INSTITUTE OF TECHNOLOGY

reservoir	odor	wall	wash
sulfide	clean	combined	CSO

KEY WORDS USED TO SEARCH DATABASES EXAMINED AT CRERAR LIBRARY

reservoir	wall	wash	clean
combined	sewer	overflow	CSO

RESULTS AND DISCUSSION

Current O'Hare CUP Reservoir Cleaning Procedures

The current practice, following dewatering of the O'Hare CUP Reservoir, is to plough the sludge to the reservoir drain area using a front-end loader or snow plow. Remaining material is hosed to the drain area which empties into the TARP system. This flushing can be performed using effluent from the Kirie WRP, water from Higgins Creek or city water. This system has been effective in the few times it has been used.

Current Quarry Debris Cleaning Performed by Material Service Corporation in Chicago Area Quarries

Material Service Corporation currently uses vacuum sweepers to clean pavement around its concrete plants, aggregate yards, and quarries (anon., 1990). The vacuum sweepers (Vac-All Models E5-13BD) are powerful enough to pick up spilled aggregate, along with dirt and debris. The sweepers are operated at 3-8 miles per hour but are truck mounted and can be moved at highway speeds from one location to another. Each of the sweepers has a thirteen cubic yard capacity. Using a vacuum sweeper, a ready mix yard requires 3/4 to 2 1/2 hours to sweep.

CSO Holding Tank Washdown and Cleaning Procedures

Little direct information appears to be available on these procedures. The available information concerns systems much smaller than that contemplated by the District. Schoettle and Jamocian (1997) reported that in New York City (Brooklyn and Queens) hydrogen sulfide emissions were highest during CSO storage tank cleaning operations. Cleaning operations were performed using an overhead spray cleaning manifold. Hydrogen sulfide concentrations exceeding 50 ppm were recorded during the cleaning operations.

Parente and Stevens (1997) compared four methods for cleaning CSO tanks in Sarnia, Ontario:

1. Manual cleaning. This option involves the standard practice of cleaning the tank with manual equipment such as hose, push broom, and shovel. Hoses are used to flush the tank floor. Approximately 600 m^3 of water was required to clean the tank floor with a surface area of 3,440 m^2.

2. Automatic flushing spray systems. This system utilized spray nozzles oriented in such a manner that the spray from the nozzles cover the entire floor area. A "large volume of water at relatively high pressures" assures scouring of the

sediments. The floor must have a lateral slope of 10 percent to ensure effective sediment transport. Approximately 600 m^3 of water, the same amount as used for the manual cleaning procedure, is needed.

3. Flushing wave system using external water tanks. This option consists of a flushing tank. Fourteen flushing tanks, each using a volume of 8.8 m^3 water for a total of 123.3 m^3 of water, are used for each flushing event. The system requires a slope of 1-2 percent to be effective.
4. Flushing wave using CSO water (Hydroself). This system is similar to the flushing wave systems, and uses the same 1-2 percent slope and floor configuration. The difference between the two systems is that this system uses a portion of detained sewage to flush the tank.

A comparison of costs is presented in Table 3.

The advantages of each system are as follows:

ADVANTAGES OF MANUAL CLEANING (hose and shovel)

1. Flexibility in level of cleaning.
2. Effective cleaning method.
3. Low capital cost.

TABLE 3

DEVINE STREET CSO TANK FLUSHING SYSTEM ALTERNATIVE COST EVALUATION (FROM PARENTE AND STEVENS, 1997)

Alternative	Cost/Event
Manual (hose and shovel)	$6,600
Spray (spray nozzles)	$1,548
SFT (flushing wave system) (external water source)	$378
Hydroself (flushing wave system using detained sewage)	$250

ADVANTAGES OF FLUSHING SPRAY SYSTEM (spray nozzles)

1. Automatic/semiautomatic.
2. Minimal tank entry required.
3. High level of cleaning achieved.
4. Moderate maintenance cost.
5. Can be placed in most facilities.

ADVANTAGES OF FLUSHING WAVE SYSTEM USING EXTERNAL WATER SOURCE (sediment flushing tanks)

1. Automatic/semiautomatic.
2. Personnel entry not required for cleaning.
3. Relatively small amount of flushing water required.
4. Low maintenance cost.
5. Water conservation.

ADVANTAGES OF FLUSHING WAVE SYSTEM USING DETAINED SEWAGE (HYDROSELF)

1. Automatic/semiautomatic.
2. Personnel entry not required for cleaning.
3. High level of cleaning achieved.
4. Uses detained sewage, no external water source required.
5. Low maintenance cost.

6. Easy accessibility for maintenance or replacement of parts as it is installed at floor level.
7. Can be applied to long flushways or installed in series.
8. More water for flushing.
9. Total water conservation.
10. Minimization of treatment requirements.

The disadvantages of each system are as follows:

DISADVANTAGES OF MANUAL CLEANING (hose and shovel)

1. Worker entry required and working in hazardous environment.
2. High maintenance costs due to tedious labor.
3. Large volume of water needed for cleaning.
4. Adds additional water to treatment requirements.

DISADVANTAGES OF FLUSHING SPRAY SYSTEM (spray nozzles)

1. High capital cost.
2. Some personnel entry involved and working in hazardous environment.
3. Large volume of water needed for cleaning.
4. Nozzle adjustments to be maintained to achieve high level of efficiency.
5. Tank must be cleaned in small sections.

6. Adds additional water to treatment requirements.

DISADVANTAGES OF FLUSHING WAVE SYSTEM USING EXTERNAL WATER SOURCE (sediment flushing tanks)

1. Moderate to high capital costs.

2. Installation 3 to 6 meters above invert of tank.

3. Length of flushway limited to 50-60 meters.

4. Adds additional water to treatment requirements.

DISADVANTAGES OF FLUSHING WAVE SYSTEM USING DETAINED SEWAGE (HYDROSELF)

1. Moderate capital cost.

The authors indicated that the cities of Essen, Konstanz, Wurzburg, Augsberg, and Eschwege in Germany use flushing systems along with several cities in Switzerland. The tanks are usually only a few thousand cubic meters.

Another possibility is removal of reservoir sediments by hydrosuction dredging without removing the overlying water (Hotchkiss and Huang, 1994). The method is similar to traditional hydraulic dredging except the difference between the upstream and downstream water levels provides the energy for the system instead of a mechanical pump. The District has used hydraulic dredging in Fulton County with limited success.

Santen (1994) indicated that pressure hose cleaning (2220 p.s.i.) followed by vacuum (combination jetter-vacuum truck) was satisfactory for cleaning an underground potable water storage reservoir in Indian Head Park, Illinois. The work was performed by National Power Rodding Corporation of Chicago. No cost estimate was given.

CONCLUSIONS

1. Manual cleaning has too many operating disadvantages and is too costly to be considered further.
2. Sweeper trucks are unlikely to be an effective method to remove liquid sludge from McCook Reservoir. The Material Service experience with this cleaning method is not relevant or practical for further consideration at the McCook Reservoir.
3. Flushing spray systems would appear to be a possible cleaning alternative for further consideration.
4. The use of a flushing wave system to remove sludge accumulations would appear to be a possible cleaning alternative for further consideration.
5. Removal of sludge using front-end loaders or ploughing devices followed by flushing or hosing would appear to be a possible cleaning alternative for further consideration as it is currently being used by the District at another facility, the O'Hare CUP Reservoir.

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