ASSESSMENT OF SEWERS AND DRAINS AT SLDS

BACKGROUND

The historical configuration of the sewer system during MED/AEC operations at SLDS from 1942 through 1957 is difficult to discern, especially the on-site portion at SLDS. Given the progression of operations--K1E and the Main Plant (the 50 series buildings) to Plant 4 (now Plant 10) to Plants 6 and 7, much of the superstructure used for MED/AEC operations has been demolished and the underground utilities abandoned or plugged. The columbium-tantalum processing has a similar history--a long term operation with multiple capital improvements over the years. The drawings received from Mallinckrodt were beneficial in identifying portions of the former layout, but many of the drawings were revised to reflect reconfigurations subsequent to the MED/AEC era and the early days of the C-T process. Consequently, records of the previous configurations and abandoned or plugged lines were often lost during these drawing revisions. With a depth of soil contamination that generally exceeds 4 feet at SLDS, the sections of these old lines that are in accessible contaminated areas should be easy to detect and easy to remove during remedial action (assuming an "action" alternative is selected). Once a contaminated line is discovered, a variety of techniques can be used to trace the line (dyes, smoke, radio transmitters) beyond the extent of contaminated soil excavation. Sections of abandoned sewer lines under present-day superstructure, however, present significant challenges to positively locating and quantifying contamination levels in all present and former sewers.

A brief primer on sewage conveyance systems:

- building sewers empty into lateral sewers;
- laterals feed mains;
- mains discharge into trunk lines;
- trunk lines feed interceptor sewers;
- sewer diameters in gravity flow systems always increase in the direction of flow, starting with individual drains that are usually 2 to 4 in. diameter, building sewers that are usually 4 to 6 in. diameter, with laterals, mains, trunks, and interceptors sized according to the design flow rates;
- changes in size, direction, or slope of sewer lines less than approximately 48 in. diameter are usually accomplished in manholes;
- combined sewer systems are always gravity flow systems to preclude the need for immense pumping systems (in lieu of localized flooding) during heavy storm water flows.

HISTORY

Before the Bissell Point Treatment Plant (located approximately 1 mile north of SLDS) went on line December 17, 1970, most process, storm, and sanitary effluent for St. Louis was collected in a combined sewer system (i.e. process, sanitary, and storm effluent all flow in the same conduit) for discharge directly to the river through one of approximately 90 municipal outfalls. Plants 1 and 2 apparently fed a collection pit which drained into a private Mallinckrodt sewer which ran adjacent to a municipal sewer trunk line under Salisbury St. Excess flow from the private sewer went into the adjacent trunk line. Available information shows the two lines had separate river discharges as of 1957, with the private sewer apparently extending 170 ft further into the river than the municipal discharge. As of 1973, the drawings show the collection pit being pumped to the Plant 7W retention basins with the excess flow from the pit entering the municipal trunk line. Also, the private sewer and trunk lines are shown merging near the river levee with only one river outfall--the municipal discharge. The Mallinckrodt sewer was abandoned some time between 1966 and 1973. No sampling was conducted around either of the Salisbury St. discharges as part of SLDS characterization.

Effluent from Plants 5, 6, and 7 was discharged through one of two private Mallinckrodt sewers along Destrehan St. Drawings show a 15-in. line along the north side of Destrehan that discharged to the river. The line was plugged approximately 200 ft upstream of the outfall some time prior to the mid 1970s so the previous contributors to this line and the time of use cannot be determined. The 30-in. line on the south side of Destrehan St. is still in use, although it no longer discharges directly to the river (see the Current Status section). The contaminated river sediment (up to 1,100 pCi/g of Ra-226 and 160 pCi/g Th-230) identified in April of 1989 (when the river level was extremely low due to several years of drought) was collected in the vicinity of the Destrehan St. outfalls.

Some of the letters in the C-T licensing documentation reference the processing of euxenite at SLDS under a separate AEC license which expired in 1960, a year before the C-T process was initially licensed. Euxenite is an ore containing columbium, tantalum, uranium, thorium, yttrium, cerium, calcium, and titanium. We are attempting to obtain the license and any available documentation for this euxenite process. A Mallinckrodt representative said that euxenite was higher in radioactivity than the commercial C-T feed materials and was processed for the columbium and tantalum content under contract to the government. After the government's needs were fulfilled, Mallinckrodt realized the commercial potential for the products and began their own C-T process using tin slag, initially.

The Mont Mason report on MED/AEC processing states that "process water, sanitary wastes, and storm water all went to common sewers which flowed directly to the Mississippi River," and that "there was no known incident of massive release of uranium or other radioactive material to plant process sewers, or known incident of accidental release of materials to cause gross contamination of adjacent private or public property." Based on the presence of above-guideline contamination in soil and sewers as well as on building surfaces, roofs, adjacent properties and Mississippi River sediment at levels above guidelines, it is apparent that the nominal releases of radioactive material contained sufficient concentrations of several isotopes to spread contamination some distance from the sources both at and below grade at SLDS.

The predominant materials of construction for the sewers underlying SLDS is vitrified clay pipe (VCP) and vitrified brick since they are inherently acid and alkali resistant and inexpensive. VCP has a bell fitting at the upstream end into which the tapered end (spigot) of the upstream pipe section is inserted. At Mallinckrodt, the joints have been sealed with bituminous tar, cementitous mortar, or lead collars. The bricks are set in similar bituminous or cementitous materials. These sewers are often leaky due to the fittings, cracking of the brittle clay pipe during installation, and differential settlement which ruptures the pipe or breaches the fittings. For sewers carrying radioactive process waste, the likely result was exfiltration and contamination of surrounding soil at some locations along the pipe. This is substantiated by the observations of the permanent FUSRAP representative at SLDS who has assisted Mallinckrodt in numerous excavations in and around former MED/AEC process areas. Most recently, the excavations both north and south of the 50-series buildings have turned up abandoned contaminated sewer lines surrounded by soil that is contaminated at the level of the sewer and below, indicating exfiltration from the line.

After Bissell Point went on line, all dry weather sewer flow was collected for treatment prior to release to the Mississippi River. Industrial dischargers were required to obtain permits from the Metropolitan St. Louis Sewer District (MSD). Mallinckrodt's discharge permit has always included limits on radioactivity due to the C-T waste stream. Mallinckrodt's current permit requires them to provide MSD with "a summary of the number of containers of such [radioactive] waste discharged, the volume of each container discharged and the results of monitoring each container for gross Alpha and gross Beta particles prior to discharge. Discharge of this wastewater shall be at a rate that will not cause the influent at the Bissell Point Treatment Plant to exceed the 1 Curie per year limit stated in MSD ordinance 8472."

Several years ago Mallinckrodt did a study of residual radioactivity in sediment at the Bissell Point Plant (we are attempting to obtain a copy of this study from Mallinckrodt). Apparently, one reason for the study was that Mallinckrodt periodically drains their 1.1 million gallon retention basins in Plant 7W and washes the residual sludge into the sewer system. With a solids deposition rate of 1,800 lb/day, the basins require desludging at least quarterly. A 1985 analysis of the basin sludge (Mallinckrodt samples the sludge and provides analyses results to MSD prior to desludging) indicated concentrations of uranium in the solid fraction of 7 pCi/g and gross beta radioactivity in the liquid fraction of 140 pCi/l. MSD incinerates all solids that are removed during sewage treatment at Bissell Point. The analyses performed on the ash do not routinely include radionuclides, but under certain circumstances (e.g. following desludging of Mallinckrodt's retention basin) radiological analyses are performed, though they are apparently limited to Ra-226 and Ra-228.

CONTAMINANT SOURCES

There were at least three operations that dealt with radioactively contaminated materials that could be responsible for contamination in sewers and drains: the MED/AEC contract work; the C-T processing under license number STB-401; and the euxenite processing under source material license number 226. The original feed material involved in the MED work was uranium black oxide (U_3O_8) which had been concentrated and stripped of daughters elsewhere. Later, the feed material also included high grade pitchblende ore (30% U) which contained all the daughters--most notably radium at 0.3 Ci/ton (which is 330,700 pCi/g). The radionuclide concentrations in the various waste and process streams cannot be ascertained with available information. Given the radionuclide concentrations associated with the FUSRAP feed and waste materials, we can readily conclude that appreciable Curies of the various radionuclides were discharged into the sewer system and subsequently the Mississippi River.

In comparison, the licensing documentation for the C-T process indicates a range of natural thorium (defined as Th-232 and Th-228 in equilibrium) of 0.06% to 2.0% by weight and natural uranium of 0.03 to 1.0% by weight in the various feed materials. Since the columbium and tantalum were the objectives of processing, the concentrations by weight of thorium and uranium in the various intermediates and wastes apparently never increased by more than 100% (i.e. maximum of 0.12 to 4.0% for thorium and 0.06 to 2.0% for uranium). Until the early 1980s, the documentation indicates that the solid waste fraction called unreacted ore (containing approximately 90% of the thorium and 80% of the uranium in the feed material) may have been discharged to the sewers, provided the radium concentration was "low." Initially, this resulted in direct discharge to the Mississippi River. Once the equalization basins--which discharge to the municipal sewer--were constructed in the mid 1970s, they received the process wastes. A large part of the solids should have settled out in the basins. All of the liquid waste fraction, containing the balance of the radionuclides, was discharged to the sewers (with the same destination over time as the solid fraction). Estimates of total annual discharge of radionuclides to the sewer included 0.83 Ci of thorium and 0.14 Ci of uranium in 1972 and 0.45 Ci of thorium in 1961. By the mid 1980s, all of the unreacted ore was being disposed of in an appropriately licensed facility, leaving only the liquid fraction to be discharged into the equalization basins. This liquid fraction was estimated to contain 0.01 Ci of thorium and 0.05 Ci of uranium in the form of soluble salts and suspended solids in 1985.

For reference, rough estimates of the total activity in the approximately 900,000 yd^3 of solid FUSRAP waste in St. Louis resulting from 16 years of processing is:

- U-238 = 188.5 Ci
- Ra-226 = 34.6 Ci
- Th-232 = 4.4 Ci
- Th-230 = 291 Ci.

No information is currently available on euxenite processing, although efforts are underway to obtain any documentation existing under the AEC license number.

<u>CURRENT STATUS</u>

All liquid effluent from the Mallinckrodt plant eventually enters the municipal sewer system. The in-plant sewer system in Plants 1 and 2 flows north to a pump pit in Plant 1 between Buildings S and T. In dry weather, the pit is pumped to the retention basins in Plant 7W; in wet weather, overflow from the pit enters the Salisbury St. municipal trunk line. Plant 10 effluent from the northeast corner of the plant flows into a main under Destrehan St. which empties into the main running north along the east side of Plant 2, which then empties into the Salisbury St. trunk line. The balance of Plant 10 effluent feeds into a main under Broadway which flows south to an unknown destination. Plant 5 effluent is collected in the Plant 7W retention basins before being pumped into the 30-in. main running east along Destrehan St. Effluent from Plants 6 and 7 also flows into the Destrehan St. main, although downstream of the retention basins. Prior to the river outfall, the Destrehan St. main has been fitted with a diversion chamber to ensure all dry weather flow is carried directly to the Salisbury St. municipal pumping station through a 42-in. interceptor sewer. During heavy runoff events, it appears that excess flow bypasses the interceptor and enters the river through a 30 in. sewer approximately 15 feet below average plant grade.

MSD has installed similar equipment in each municipal trunk line and large main in the downtown area. An interceptor has been installed to ensure collection and treatment of all dry weather flow in the municipal lines. Flow from trunk lines and mains (including the Salisbury St. pumping station) empties into a 96-in. diameter tunnel in bedrock which is approximately 70 ft. below grade as it passes under SLDS along Hall St. In times of heavy storm water flow, however, when the capacity of the interceptors is exceeded, excess flow is discharged directly to the river.

High storm water flows also result in diluted sewage being treated at Bissell Point. Neither treatment of stormwater, nor untreated discharge to the river is desirable, but St. Louis has always had a combined sewer system and the financial resources required to retrofit the entire system for separate sanitary and storm water collection is prohibitive. Since the Clean Water Act, sewer designs are generally separate (as is the case in the vicinity of HISS where storm water is discharged to Coldwater Creek while sanitary and process waste is collected for treatment at the Coldwater Creek Treatment Plant).

The process waste from SLDS that is collected in the retention basins in Plant 7W requires no formal treatment prior to the wastewater being pumped into the Destrehan St. sewer. The retention basins serve to equalize discharge rates to the sewer, allow for settling of solids, and neutralize various acidic and basic effluents. The in-plant sewer system is combined so storm water (or any liquid entering a storm drain) flows to the same destination as process waste. The retention basins have overflow weirs to allow immediate discharge to the Destrehan St. main in times of heavy flow.

Prior to 1990, at river stages above 17 ft (flood level is 30 ft, or approximately Elevation 410; average grade at SLDS is Elevation 420, for reference), each interceptor was manually valved off to prevent the river water from rising into the discharges, backing up in the system, and pouring into the interceptor and overwhelming the capacity of the treatment plant. All flow was consequently discharged directly to the river. In 1990, installation of an automated valve control system for the river discharges began to ensure all dry weather flow goes to the treatment plant, regardless of river stage.

Currently, only primary treatment is conducted at Bissell Point (the home of the largest trickling filters in the country), but a secondary treatment system using activated sludge is being constructed. St. Louis is also noteworthy in that it is one of very few cities to regulate radioactive material discharges in sewage. As previously mentioned, Ordinance 8472 limits the total activity received by each of the 14 MSD treatment plants to no more than 1 Curie per year and specifies that any radioactive material must be soluble or dispersable. The onus lies with the permit holders to accurately monitor and report the activity in their effluent. It is MSD's responsibility to integrate the monitoring reports from permit holders to ensure the 1 Curie limit is not exceeded.

CHARACTERIZATION RESULTS
Sampling and surveying of 107 catch basins and manholes during FUSRAP characterization efforts indicate a general trend toward decreasing contamination with increasing distance from the source. The most notable sources are Plant 6, Plant 7, and Plant 5 with lower amounts of contamination in Plants 1 and 2 and no contamination detected in Plant 10. The levels in the laterals around Buildings 116/117, 704/705/706/707, and 250 rapidly drop from tens, hundreds, or thousands of pCi/g in laterals and small

mains to levels of ones or tens of pCi/g as the laterals and small mains feed the larger mains and trunk lines. Specifically, in Plant 7:

- Manhole 102 in the lateral at the northwest corner of Building 706 contained sediment with 2,662 pCi/g of Th-230;
- Manhole 5 at the southeast corner of Plant 6E across Destrehan St. was the next one sampled downstream of Manhole 102 and it had Th-230 at 50 pCi/g;
- No samples were taken downstream of Manhole 5;
- Manhole 19 on the Destrehan St. main (south side) at the northeast corner of Building 700 had sediment with 520 pCi/g of Th-230;
- The next manhole downstream on the Destrehan St. main, Manhole 8 just north of Building 705, contained sludge with a Th-230 concentration of 2,600 pCi/g;
- Downstream samples at Manholes 2 and 3 contained 6 pCi/g of Th-230 and sum-of-the-ratios contamination, respectively. Manhole 2 is where the diversion chamber was installed to route flows into the 42-in. interceptor sewer to the Salisbury St. pumping station;
- No samples were taken downstream in the 42-in. sewer;
- The river sediment samples were the only ones taken downstream of Manhole 3.

In Plant 6:

- Manholes 11, 13, 14, 15, 100, and 101 in the sewer around Building 116 had concentrations ranging up to 270 pCi/g of U-238 and 150 pCi/g of Th-230. These laterals join the Destrehan St. main at Manhole 8.

There was one contaminated sample from the west side of Plant 6 that was not bounded by clean samples and three anomalies:

- Manhole 29 contained 43 pCi/g of Th-230. The line it is on flows west from the fuel tank area to the 27-in. main on the east side of Plant 1, which empties into the Salisbury St. trunk line.
- Manholes 9, 28, and 33 are apparently not sewer manholes. Instead, they are water main valve pits or meter boxes that have accumulated contaminated sediment. Manhole 33 has only sum-of-the-ratios contamination while Manhole 28 has Ra-226 at 11 and Th-230 at 73 pCi/g and Manhole 9 has Ra-226 at 17, Th-232 at 15, and Th-230 at 71 pCi/g.

Only three manholes were sampled in Plant 5 and all three samples were above guidelines:

- Manhole 82 between Buildings 240 and 250 had U-238 at 190 pCi/g, Ra-226 at 930 pCi/g, Th-232 at 640 pCi/g, and Th-230 at 510 pCi/g;
- Downstream samples at Manholes 74 and 75 had sum-of-the-ratios contamination and Ra-226 at 8 pCi/g, respectively.

Manhole 81, which is between Manholes 82 and 75, did not contain sufficient sediments to sample. Direct gamma instrument readings, howver, were as high as 417,000 cpm. For reference, the maximum readings from Manholes 74, 75, and 82 were 117,000, 7,000, and 887,000 cpm, respectively.

Plant 5 sewer contamination was bounded by a clean sample at the pump station for the retention basins.

The levels of contamination in the sewers in Plants 1 and 2 are not as high as those in Plants 5, 6, and 7. Maximum levels of each of the four isotopes occurred at four different locations and were in the tens of pCi/g range.

There are at least 4 cases, however, where contamination is not bounded in Plant 1:

- Manhole 59, which feeds the 21-in. line that discharges into the pump pit between Buildings S and T, had 30, 16 and 7 pCi/g of U-238, Th-230, and Ra-226, respectively;
- Manholes 47 and 48 on the north side of Mallinckrodt St. south of Buildings 6, 7, and 8, which feed the same 27-in. line on the east side of Plant 1 as Manhole 29, has sum-of-the-ratios contamination;
- Manhole 108 at the southwest corner of Building 50, destination unknown, had 33 pCi/g of Th-230; and,
- Manhole 39 in the middle of Destrehan St., south of Building 501, which feeds a 21-in. line that runs along the east side of Plant 2 that becomes the previously mentioned 27-in. line along the east side of Plant 1, had 10 pCi/g of Th-230.

Only one sample was taken in Plant 10, proper, and it was below guidelines. All five additional samples taken around the periphery of Plant 10 along Broadway, Destrehan, and Angelrodt Streets were below guidelines as well.

Based on the observation that contamination levels decrease with increasing distance from the site, the possibility that an accumulation of contaminated sediment of appreciable quantity (e.g. to cause MSD to exceed their 1 Curie per year limit, allowing for known radioactive discharges) seems quite remote. With increasing development of the area and collection of all effluent for treatment (vs. point discharges to the river), the load on the system has increased. This would increase the likelihood that most of the loose deposits in the system have already been scoured away.

Focusing specifically on FUSRAP, during MED/AEC operations at SLDS the Mississippi River exceeded flood stage (river stage greater than 30 ft, or Elevation 410 ft) four times. Since AEC operations ceased at SLDS in 1957, there has been at least four more major Mississippi River floods. Given the fact that river water flows into the sewer system beginning at a river stage of 17 ft, these floods should have flushed out or diluted accumulations of sediment.

CONCLUSIONS AND RECOMMENDATIONS

Sewers running through areas already identified as contaminated will be evaluated and properly dispositioned during remedial action (assuming an action alternative is selected). Areas not remediated in lieu of supplemental standards (e.g. inaccessible areas under superstructure) present some risk that abandoned drain lines will contain material of significantly higher radiological concentrations than soil characterization data reflect.

Similarly, some areas on site that have not been characterized may actually be contaminated above guidelines due to exfiltration from contaminated sewers and the presence of abandoned contaminated sewers that are not detectable from the surface. Recent Mallinckrodt excavations near the 50-series buildings in areas FUSRAP characterization data indicate as clean, have uncovered such abandoned drains, debris, and underlying soils that are significantly above guidelines.

The areas around the Mississippi River outfalls from Salisbury St. trunk line and the old Mallinckrodt sewer at Salisbury St., if it can be located, should be sampled. The previously detected contamination in the river sediment is apparently from the two Destrehan St. outfalls. It appears the MED/AEC effluent from Plants 1 and 2 was discharged into the river via the Salisbury St. sewer and/or the old Mallinckrodt sewer outfall. Consequently, manholes along both the MSD and Mallinckrodt Salisbury St. sewers and the Plant 1 pump pit should also be sampled. In addition, the sewer running along the east side of Plants 1 and 2 should be sampled since it is the next conduit downstream from several contaminated manholes.

The contamination discovered in water main valve pits and meter boxes (Manholes 9, 28, and 33) indicates a potential hazard not previously assessed. While the valve pits and meter boxes do not provide the opportunities for migration that sewer manholes provide, they do present opportunities for workers to unknowingly contaminate themselves and ingest, inhale, and/or spread contamination.

If further sampling of manholes and water main valve pits and meter boxes is instituted, the effort should include more of the catch basins in Plant 10. The location of the one sample obtained from Plant 10 does not coincide with the location of any sewer or water main shown on available drawings. Consequently, it appears the sewer system in that Plant 10 may not have been assessed at all.

We are attempting to obtain the results of the Mallinckrodt study of contamination in the sediment at Bissell Point to assist in determining what, if any, additional sampling may be required.

As a minimum, sewers in which contamination was not bounded by samples below guidelines should be traced prior to remedial action to more definitively quantify the extent of contamination in the sewer system.

This brief assessment of the sewers and drains at SLDS has raised several significant issues which will be pursued as additional information becomes available (e.g. historical information from Mallinckrodt and MSD, conclusions from our research into the C-T process, the Mallinckrodt study of sediment at Bissell Point, etc.).

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