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Subject:
Technical Memorandum 4 – Effluent Disposal Options
Wastewater Treatment Capacity and Effluent Disposal Study
Murfreesboro Water and Sewer Department

The primary objective of Technical Memorandum (TM) 4 is to evaluate various options for discharge and disposal of treated wastewater effluent. Potential locations were identified for reuse and zero discharge effluent disposal from either the Sinking Creek Wastewater Treatment Plant (WWTP) or the proposed decentralized treatment plants. This technical memorandum also provides a summary of the current Murfreesboro Water and Sewer Department (MWSD) repurification system, a review of reuse capacity increases at the Sinking Creek WWTP, and an evaluation of the benefit of advanced treatment processes for higher quality effluent.

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1. Summary of Existing Effluent Disposal

1.1 Surface Water Discharge

As discussed in Technical Memorandum 2 (*Regulatory Evaluation*), the options are limited for local stream discharge of wastewater effluent due to the large number of impaired and/or low flow streams in the Murfreesboro area. The two options considered most acceptable by TDEC are a seasonal or continuous discharge into the earlier-proposed outfall location on the East Fork Stones River and a seasonal expansion of the existing discharge to the West Fork Stones River with no increase in contaminant load. With a seasonal discharge permit, an effluent disposal location must be identified for warm weather (low flow) months.

1.2 Repurification System

The City of Murfreesboro Wastewater Facilities Plan (SSR, 2002) recommended the implementation of a non-potable reuse system for effluent disposal above the plant's rated capacity. The Murfreesboro Water and Sewer District (MWSD) has since developed a repurification system that currently disposes of between 3 and 6 mgd of wastewater on an average day. Treated plant effluent is diverted from the post-aeration basins, dosed with sodium hypochlorite to produce a chlorine residual, and pumped to the onsite 500,000 gallon repurification water elevated storage tank. Repurified water is currently distributed through the Phase 1 pipe networks (as identified in the 2002 Wastewater Facilities Plan) with lines extended to the Medical Center Parkway, Old Fort Golf Course, Shoppes at Murfreesboro, Shoppes at Gateway Corner, Oaks Shopping Center, Siegel High School, Rutherford County Chamber of Commerce, Siegel Park at Cherry Lane, and other users for beneficial reuse.

The Jordan and Coleman Farms are located approximately 1.6 and 3.6 miles northeast, respectively, of the Sinking Creek WWTP. In 2005, repurified lines were extended to Jordan and Coleman Farms for dedicated land application. Repurified lines were then installed on Jordan Farm in 2008, which is currently being used for spray application of treated wastewater. Since the system is considered complementary to the permitted discharge, the hydraulic application rate is limited only by the avoidance of surface water runoff. Coleman Farm has not yet been developed for a repurified water system, but plans have been developed to install a land application system on the property.

Demand for the MWSD repurification water has steadily increased. From 2007 to 2010, the average daily flow to the repurification system increased from 1.51 mgd to 3.93 mgd. Figure 1-1 illustrates the average and maximum daily flow to the repurification system between 2007 and 2010. Concurrently with the steady growth in the repurified water flow over time, Figure 1-1 also illustrates that there is generally a decline in repurified water demand during the colder months. This phenomenon is typical of reclaimed water systems, since irrigation demands are lower in the winter.

MWSD's repurified water system is categorized as beneficial reuse by TDEC. Beneficial reuse is advantageous as it allows for potable water conservation and for non-potable water to be available to the consumer at a lower price than potable water. However, since the demand for beneficial reuse fluctuates seasonally, this water is not strictly accounted for at each location by TDEC on a daily basis. The repurified water system is permitted by TDEC for seasonal use, but the system is not permitted for dedicated long-term effluent disposal.

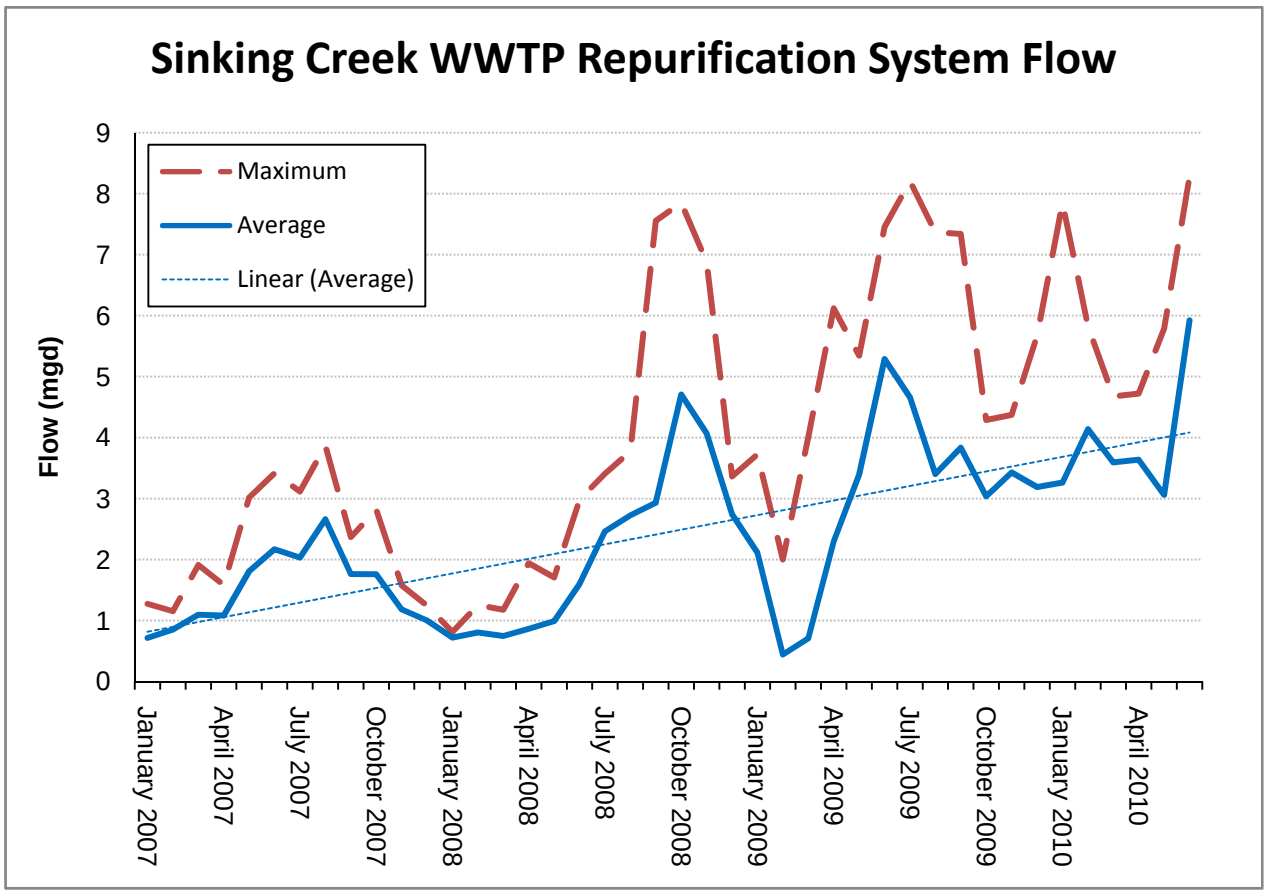


Figure 1-1: Sinking Creek WWTP Repurification System Flow

2. Land Application Effluent Disposal

Land application as a reliable effluent disposal alternative will be of particular importance to MWSD as there are limited options for allowable discharge into local surface waters. Potential locations for land application were identified from a soil study completed by MWSD in 2010. In this study, MWSD used the Rutherford County Tax Map Index System and the USDA/SCS soil surveys to find parcels greater than 30 acres with well drained and permeable soils (i.e., "favorable" soils). The majority of the selected parcels were zoned for agricultural purposes. Parcels in the process of development were not selected.

In August 2010, the next phase of the study was completed in which GIS analysis was used to narrow down the acceptable parcels. Parcels in the Smyrna, LaVergne, or Eagleville Urban Growth Boundaries or which contained a sinkhole "throat" were excluded. The percentage of total parcel area containing well or moderately drained soil was then determined for each parcel. The output from this study was the 2010 Soils Study of Potential Irrigation Sites Maps.

Hazen and Sawyer analyzed the 2010 Soils Study of Potential Irrigation Sites Maps for parcels with the highest denoted percentage range (76.6 percent to 100 percent) of well or moderately drained soil. Particular attention was paid to parcels with large areas and/or in close proximity to each other. The main locations of interest for effluent disposal are in the high growth areas, i.e., areas northeast and southwest of Murfreesboro's city center, and locations within approximately five miles of the SCWWTP to minimize pumping costs. Potential land application parcels in close proximity to each other and within these designated areas were grouped together to form eleven land application locations (indicated as L# on the following figures and tables) for effluent disposal. Figure 2-1 illustrates the general regions of these eleven locations.

The estimated repurified water capacity of each of these land application locations was determined for both spray application and subsurface drip disposal using parcel sizes from the 2010 MWSD Soil Study and the land application buffer guidelines in Chapter 16 (Design Guidelines for Wastewater Treatment Using Spray Irrigation) and Chapter 17 (Design Guidelines for Wastewater Dispersal Using Drip Disposal) of TDEC's publications on *Design Criteria for Sewage Works*. For all potential locations, the total area of each parcel was multiplied by the respective percentage of area containing favorable soils to determine the total area of favorable soil in each parcel. A general percentage of usable area for subsurface drip disposal and spray irrigation was calculated based on the buffers required by the TDEC guidelines for spray irrigation and drip disposal (provided in Table 2-1). The general percentage of usable area was estimated using a square 200-acre parcel and was calculated for parcels with and without a stream.

An analysis was completed in GIS to determine the actual parcels with intersecting streams. The applicable usable area percentage (based on type of land application and with or without a stream) was then multiplied by the previously determined parcel area containing favorable soil for each parcel to determine the total usable drip disposal and spray irrigation areas for all parcels of interest. This calculation results in a conservative estimate of usable area. These values were then multiplied by the maximum application rate of 0.25 gallons per day per square foot (gpd/SF), designated in the TDEC land

application guidelines, to determine the flow rate allowable for drip disposal and spray irrigation. The usable area and allowable flow rate determined from these calculations for both spray irrigation and subsurface drip disposal is presented in Table 2-2 for the eleven proposed land application locations. Identical calculations were completed for the Jordan and Coleman Farms.

The estimated purchase price for each location will be included in the capital costs determined for each disposal alternative in TM 7. According to MWSD, the average cost of land in the Murfreesboro area ranges from $25,000 to $30,000 per acre.

Table 2-1: TDEC Land Application Requirements

	Buffer Zone Requirements (feet)		Wet Weather Storage
	Property Boundary	Streams	
Spray Application [1]	300	150	30 days [2]
Sub-surface Drip Disposal	10	25	N/A

[1] *Buffer values designated for open fields with sprinkler systems were used for spray irrigation.*
[2] *The 30 day storage is a rule-of-thumb estimate. A hydrologic mass balance will determine the exact volume of wet weather storage required.*

There is a significant difference in the buffer requirements between drip disposal and spray irrigation, likely because of the potential for spray to be carried offsite by wind or other influential factors. Spray irrigation is typically a lower capital cost alternative than drip disposal, so another option for MWSD is to land apply using spray irrigation in the center of a site and then utilize subsurface drip disposal in the large spray buffer zones around the perimeter of the site. In terms of volumetric capacity, the spray/drip combination will be very similar to the volumetric capacity of drip disposal (Table 2-2). If there was a stream within the parcel, the flow rate values will be approximately 5 percent lower than those for drip disposal depending on the placement of the stream. The disadvantage to the spray/drip combination is the hydraulic balance required between the two systems, with one option being the installation of two separate pumping systems. Additionally, drip disposal systems are inherently maintenance intensive due to limited access and clogging issues. A spray/drip combination would also still require a wet weather storage reservoir for the spray irrigation portion of the system.

Table 2-2: Maximum Allowable Flow Rate for Land Application Locations

Location	Total Area (acre)	Favorable Soil Area (acre)	Drip Usable Area (acre)	Spray Usable Area (acre)	Drip Flow Rate (mgd) [1]	Spray Flow Rate (mgd)
Southwest Options						
1	271	210	193	116	2.1	1.3
2	242	211	195	120	2.1	1.3
3	178	170	162	108	1.8	1.2
1,2,3	691	591	550	345	6.0	3.8
1,2	513	421	388	237	4.2	2.6
2,3	420	381	357	228	3.9	2.5
1,3	450	380	355	224	3.9	2.4
4	504	454	418	252	4.6	2.7
5	370	309	285	171	3.1	1.9
6	194	185	175	117	1.9	1.3
Sinking Creek Options (within 5 miles)						
7	258	224	209	133	2.3	1.5
8	312	286	268	171	2.9	1.9
Coleman Farm	400	300	276	166	3.0	1.8
Jordan Farm	200	148	141	94	1.5	1.0
Northeast Options						
9	692	583	538	328	5.9	3.6
10	350	317	301	202	3.3	2.2
11	297	256	235	142	2.6	1.5
9,10	1042	900	839	529	9.1	5.8
9,11	989	839	773	470	8.4	5.1
10,11	647	573	537	343	5.8	3.7
9,10,11	1339	1156	1075	671	11.7	7.3

[1] *A spray/drip combination would result in values very similar to the volumetric capacity of drip disposal.*

Proposed Outfall #002

L7

L9, L10, L11

L8

Existing Outfall #001

1 mile

2 miles

3 miles

4 miles

5 miles

6 miles

7 miles

8 miles

9 miles

10 miles

L1, L2, L3

L6

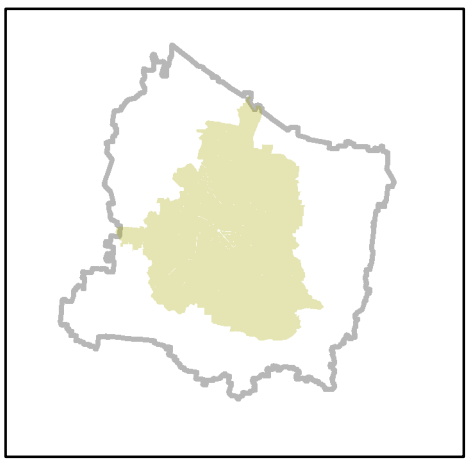
L4

L5

N

Miles

0 1 2 4



Legend

- WWTP
- Repurified Tank
- Roads
- Repurified Water Line
- Large Stream / River
- Small Stream / Creek
- Lake / Pond
- Jordan Farm
- Coleman Farm
- Sewer Districts

Figure 2-1
Potential Land Application Locations (L#)

Wastewater Treatment Capacity and
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Murfreesboro Water and Sewer Department

3. Other Effluent Disposal Alternatives

There are several other effluent disposal options that should be considered for applicability and feasibility. Constructed wetland disposal, aquifer recharge, deep well injection, and high rate infiltration are discussed in the following sections.

3.1 Natural or Constructed Wetland Disposal

According to the U.S. Environmental Protection Agency (USEPA) Guidelines for Water Reuse (2004), using wetlands for treated wastewater disposal is considered a beneficial option if wetlands are “created, restored, and/or enhanced” or are used as a disposal alternative for a reuse system during wet-weather months (USEPA, 2004). Wetland disposal benefits include enhanced water quality and low operating costs. However, this disposal option also requires an extensive amount of land. In Rule 1200-4-7-.03, TDEC indicates that constructed wetlands may be used for wastewater treatment but is not specific on their use for effluent disposal.

To use constructed or natural wetlands for dedicated effluent disposal, hydraulic loading rates would be calculated based on wetland type, vegetation, slope, and nutrient loading. In Florida, for example, natural wetlands can receive up to 2 inches per week and hydrologically-altered wetlands can receive up to 6 inches per week depending on the dominant vegetation (Dortch, 2011). Construction costs would likely be comparable to, if not greater than, a land application system.

3.2 Aquifer Recharge

Aquifer recharge can either be used for the final disposal of treated wastewater effluent or for storage and subsequent reclamation. TDEC listed aquifer recharge as an alternative technology in Rule 1200-22-2-.02, indicating that it is a recognized option for wastewater disposal. However, Murfreesboro’s underlying area contains limestone conducive to karst formation (Thornberry-Ehrlich, 2009). These geologic features allow groundwater to travel for great lengths without filtration by rock and soil layers, increasing potential for surface water contamination (Rutherford-Williamson-Davidson Power Supply Improvement Project, 2008). Therefore, aquifer recharge is likely not a practical discharge option for the Murfreesboro area.

Land application indirectly results in groundwater recharge. However, aquifer recharge is not an intentional result of this application. Conversely, high rate infiltration and deep well injection are intentional aquifer recharge practices, and are discussed in the following subsections.

3.2.1 High Rate Infiltration

High rate (or rapid) infiltration is the disposal of treated wastewater into a basin containing high permeability soils at a high hydraulic loading rate (Crites, 2000). The TDEC regulations do not currently indicate whether high rate infiltration is an allowable means of effluent disposal. However, TDEC only allows a maximum hydraulic loading rate of 0.25 gpd/SF for land application via spray irrigation or

subsurface drip disposal. As high rate infiltration is similar to these processes but with increased loading rates (typically 1.3 to 10.2 gpd/SF), this method is not likely to be a viable disposal option for MWSD.

3.2.2 Deep Well Injection

Deep well injection is the direct underground pumping of treated wastewater, usually into a confined aquifer (USEPA, 2004). Under Rule 1200-4-6-.03 in the TDEC regulations, “the use of any well to dispose of water carrying human waste, household or business wastes, raw sewage or the effluent from any septic tank or other sewer system of any kind” is prohibited, making this option infeasible as an effluent disposal alternative for MWSD.

3.3 Beneficial Stream Discharge

Stream flow augmentation is the process of supplying additional water to a stream to increase the base stream flow rate. The difference between stream flow augmentation and surface water discharge is that augmentation is completed with the intention of providing a beneficial stream impact (USEPA, 2004). Although wastewater effluent is commonly treated as a source of contamination, it can also provide positive effects to the streams into which it is discharged. Reclaimed water (discharged treated effluent) may be the principal source of stream flow in some areas and “is a reliable water source that can be supplied constantly for aquatic and riparian habitat enhancement” (Asano, 2007). However, stream augmentation is not permitted as a dedicated disposal option in many states.

In order to assess the effects of stream flow augmentation with treated wastewater, water quality testing and modeling can be utilized. For example, if the low dissolved oxygen concentration in a stream is the primary reasoning for a restriction on additional wastewater effluent, a model can be used to simulate the expanded discharge from the wastewater treatment plant and its impacts on the downstream dissolved oxygen concentration. An increase in treated wastewater to a low flow stream can increase the stream dissolved oxygen concentration, which in turn can result in the determination of additional assimilative capacity. However, an evaluation should also be completed to determine if increased wastewater discharge (particularly to a low flow stream) would increase any contaminant concentrations above regulated levels.

For long-term effluent disposal planning, MWSD should consider commissioning a water quality model development study to evaluate the technical feasibility of increased assimilative capacity in the West Fork of the Stones River. TDEC has indicated that it will not develop the total maximum daily load (TMDL) for another decade for this reach of the West Fork. If commissioned by MWSD, an initial scoping model can be completed in approximately six months, with the follow-up detailed model, site study, and permitting process taking up to two years. This modeling effort would provide information on whether an expansion of the Sinking Creek WWTP discharge to the West Fork of the Stones River is a viable effluent disposal option.

3.4 Surface Water Discharge

3.4.1 J. Percy Priest Reservoir

Several surface water discharge options have been previously considered by MWSD. One option was pumping treated effluent from the Sinking Creek WWTP to the J. Percy Priest Reservoir (Wastewater Facilities Plan, 2002). Based on communications with MWSD staff, the J. Percy Priest Reservoir option was deemed impractical because of its current use as a drinking water supply source.

3.4.2 Cumberland River

Another surface water discharge option previously considered by MWSD was to pump wastewater effluent to the Cumberland River. This option was determined to have very large capital costs in the Wastewater Facilities Plan (SSR, 2002). However, using the Cumberland River for discharge may still be a feasible option. The Cumberland River is approximately 24 to 28 miles from the Sinking Creek WWTP, depending on the route and outfall location. Since the Cumberland River is a high volumetric flow surface water, it likely has sufficient assimilative capacity for a discharge from MWSD. A Cumberland River surface water discharge would require a new NPDES permit to be issued by TDEC, which ultimately would require a public comment period, and would be subject to the anti-degradation guidelines. It would also be necessary to check for existing drinking water intakes to make sure wastewater effluent was not directly impacting the water quality of any downstream water treatment plants. Depending on the environmental impacts, the permitting process could be lengthy and range from one to three or more years.

3.5 Benefit of Advanced Treatment Processes for Additional Reuse Opportunities

Advanced treatment can be defined as the inclusion of any additional treatment processes beyond traditional secondary treatment and may consist of a specific conventional treatment process (i.e., filtration, nitrification, denitrification, coagulation, sedimentation) or may include newer treatment alternatives, such as carbon adsorption, phosphorus removal, or membrane processes (USEPA, 2004). Advanced treatment technologies may assist in increasing the rate of wastewater reuse if there are customers interested in using reclaimed water for a particular application that requires a higher quality of water (e.g., a cooling tower that requires specific water quality parameters).

Advanced treatment will provide an increased quality of effluent, but higher quality does not always equate to additional reuse opportunities for customers. To determine if advanced treatment would be advantageous to the MWSD, a detailed survey of available beneficial reuse customers should be completed to determine if the projected increase in the amount of effluent disposal used by the number of customers interested in higher quality water outweighs the cost of the additional treatment processes. Unless a significant user is found to justify the increased capital cost, the existing repurification system will not require additional treatment beyond that already in operation at the Sinking Creek WWTP.

4. Summary and Recommendations

Several alternative disposal and discharge options have been discussed in this TM, including effluent disposal via land application, wetland disposal, aquifer recharge, high rate infiltration, and deep well injection. Other considerations are surface water discharge options, such as the East and West Forks of the Stones River, the J. Percy Priest Reservoir, and the Cumberland River.

In a Tennessee Water Reuse Inventory (2010) presented by the Center for the Management, Utilization, and Protection of Water Resources and TDEC at the Tennessee Association of Utility Districts Business conference, no Tennessee utilities were shown to use aquifer recharge, rapid infiltration, or wetlands for wastewater disposal (2010). Therefore, it is unlikely that these alternatives would be easily permitted and/or integrated as wastewater disposal methods for MWSD. Using the J. Percy Priest Reservoir for wastewater discharge was previously determined to be an impractical option due to its use as a drinking water supply source. The Cumberland River option was found in previous studies to have high capital costs but remains a feasible option.

The lowest cost options are the direct discharge alternatives. TDEC has indicated the feasibility of seasonal and direct discharges into the West and East Forks of the Stones River. MWSD should apply for planning limits for an additional seasonal/continuous discharge of 4 mgd into Outfall #001 and a seasonal/continuous discharge of 4 to 12 mgd into Outfall #002. MWSD should also meet with TDEC about commissioning a water quality model and study to evaluate the feasibility of increased assimilative capacity for a continuous discharge into the East and West Forks of the Stones River.

Land application appears to be a viable effluent disposal option for MWSD. Although land costs are high, there appear to be several feasible options for land application sites. Further evaluation should include determination of current use, identification of ownership, and exploration of site topography to determine if the selected sites are good candidates for land application.

Effluent disposal is a significant factor in long-term wastewater capacity planning. Many communities are struggling with the costs associated with using land application for effluent disposal as surface water disposal is limited or curtailed. MWSD should consider a multi-faceted approach to provide the most cost-effective long-term solution. These hybrid alternatives are discussed in Technical Memorandum 5.

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