Small wastewater treatment facilities prove vital to expand and revitalize aging developments

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ABSTRACT | In a post-Covid world, non residential uses such as retail and office space have seen precipitous declines in use, while recreational uses have experienced a noteworthy revival and offer significant redevelopment potential. Private wastewater treatment systems can be pivotal in these redevelopment projects. This article presents technical and permitting approaches to resolve wastewater treatment and disposal limitations critical to the successful redevelopment of the (effectively) abandoned Yogi Bear Campground into the new Pine Lake RV Resort in Sturbridge, Massachusetts.

KEYWORDS | Decentralized wastewater treatment, water resource recovery, groundwater discharge, sewer, Title 5, septic, redevelopment, campground, nitrogen

Over the past decades (until Covid), societal shifts in how people vacation contributed to the steady decline of a past cherished recreational activity—staying at family campgrounds. As a result, many campgrounds have scaled back activities or closed. In past practice, campgrounds often offered campsites or recreational vehicle (RV) sites that also traditionally included bathhouses and/or access to potable water. Given that these sites are rarely in areas with public utilities, these services were provided via on-site public water supply wells interspersed with small cesspools and/or septic systems. From an environmental and water supply protection perspective, this model, at typical campground sizes, is problematic relative to protecting public health and the environment, as untreated nitrogen-laden discharges from these systems can directly affect groundwater quality used for drinking water, and can also accelerate eutrophication of nearby surface water bodies. Massachusetts regulations now prohibit the use of septic systems at flows above 10,000 gpd (37,854 L/d), the equivalent of approximately 110 campsites. Unfortunately, conversion of these old (often abandoned) campsites to resort-style venues with amenities at those lower flow limits is typically not cost-effective and, therefore, these sites become abandoned or fall into disrepair.

The Pine Lake RV Resort was borne out of a vision to return the idea of family RV style camping to New England by attracting the new type of camper: families who are looking for a higher-end experience with resort-style amenities and access to sanitary facilities, often referred to as "glamping." This model has been successful in other parts of the country and, given the void in Massachusetts of family-style campgrounds, it seems this concept could succeed here as well. To make this vision a reality, updating the old "septic system model" of sewage treatment and disposal to align with current regulations would also need to be addressed, since successful site redevelopment would only be realistic if the increased scale of wastewater disposal to make the project economically viable could be addressed. At these scales, either connection into the municipal system or the use of advanced treatment, via a decentralized on-site private water resource recovery facility (WRRF), would be necessary to allow the site to expand to a scale large enough to make it a viable resort-style campground/RV park,

Pine Lake RV Resort in Sturbridge, Massachusetts

while also generating sufficient revenues to justify capital investment in upgrading the wastewater infrastructure. Since a municipal sewer was not available at this site, the development team's willingness to integrate a private on-site WRRF allowed for the property to be maximized relative to site access constraints. Scaling up the site's facilities allowed for the costs to construct this new infrastructure to be recuperated and to make this site a more attractive vacation destination. While this concept seems straightforward, design and permitting of such facilities encompass many aspects of both science and engineering and require professionals with experience and knowledge in geology, hydrogeology, hydraulics, and wastewater treatment engineering.

PROJECT DESCRIPTION

The new Pine Lake RV Resort was conceived for and built at the old Yogi Bear Campground site at 30 River Road in Sturbridge, Massachusetts. As the site was previously a campground and RV park, several on-site septic systems served the property, mainly connected to bathhouses and comfort stations, along with a system connected to the RV onboard chemical toilet dump tanks. Those systems had been in use since the park's inception and created pollution issues at the adjacent Pine Lake, its associated wetlands, and local perennial stream. Based on the site conditions, the Massachusetts Department of Environmental Protection (MassDEP) determined in 2009 that the site was not in compliance with current wastewater regulations as the total aggregate flow generated by all uses at the site exceeded 10,000 gpd (37,854 L/d) and the septic systems were degrading groundwater quality.

At that time, MassDEP determined that the maximum day design flow for the site, based in accordance with 310 CMR 15.000 (the state environmental code, Title 5) should be 35,910 gpd (136,000 L/d), which was based on the 396 camping and RV sites at the campground at the MassDEP defined sewage generation rate of 90 gpd/campsite (341 L/d/campsite). As a result, the previous owner of the park entered into an administrative consent order (ACO) with MassDEP, agreeing either to upgrade the on-site disposal systems to achieve compliance or to connect to town sewer. While Sturbridge had considered and studied extending sewers to this part of town, there was never much appetite to fund these projects, given the limited benefits to most of the town's residents and, as such, a sewer connection was never built. This is all-too-often an outcome in suburban and rural areas when municipal sewer expansions are contemplated, where local resident benefits are limited and it is hard to justify the expense to taxpayers.

Without a municipal sewer extension and given the constraints on septic system use imposed on the campground by MassDEP via the ACO, the Yogi Bear Campground was effectively shut down; declining occupancy and revenues could not support the investment necessary to upgrade the septic systems to a private decentralized WRRF. It was not until a new ownership group saw the value in restoring this site and upgrading it to its business model of high-end, amenity-rich glamping that any serious consideration was given to moving forward with the design, permitting, and construction of a MassDEP-approved WRRF. Based on the new ownership group's internal sizing metrics, it determined the best way to maximize revenue, while providing a more enjoyable and immersive experience, was for the new configuration to have a maximum of 345 sites, anticipating this would generate a maximum flow of 31,050 gpd (118,000 L/d). The reduction in camping/RV sites allowed for those areas to be converted to common amenity spaces. These upscale amenities are reserved for guests of the park and include

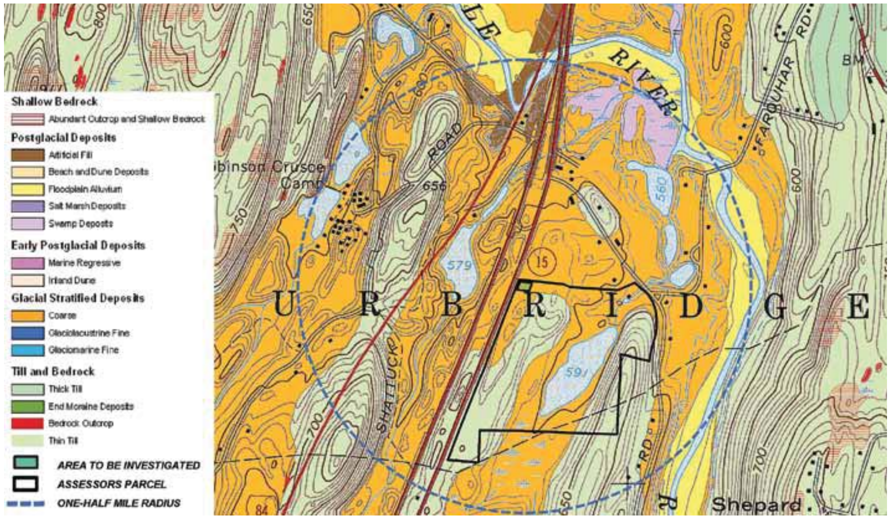

Figure 1. The site includes coarse glacial stratified deposits that were bisected by a geological formation that consisted of shallow depth to bedrock overlaid by a dense glacial till in certain locations

several high-end comfort stations (which have high-capacity laundry machines), an in-ground swimming pool with cabana space, and several large function halls that include game rooms, meeting and event spaces, outdoor patios, playgrounds, and lawn areas for outdoor games, movies, and fire pits.

SITE EVALUATION AND SUITABILITY

This project required a range of science and engineering facets, from testing and modeling of the site's geology and hydrogeology, to sewage collection and pumping to biological treatment of sewage. The critical path in designing the system was first to identify suitable soils on the site for subsurface effluent disposal and then to design, permit, and construct the private WRRF that would produce a treated effluent that meets or exceeds the MassDEP's discharge standards associated with the Groundwater Discharge Permit (GWDP) regulations (314 CMR 5.00).

The first step in this three-phase process involved the assessment of the site to determine soil and groundwater characteristics relative to their ability to successfully accept treated WRRF effluent. The initial phase included a review of soil mapping and historic soil and groundwater information to assess if there were areas of the site that might prove to be preferred for effluent disposal. The next phase included completion of soil test pits and percolation (perc) tests that were witnessed by MassDEP to determine the types and relative depths of the naturally occurring pervious soils at the site and to quantify the perc rates to develop a long-term acceptance rate (LTAR), or loading rate, for the effluent disposal system. The final phase here included groundwater conductivity testing at the site to determine the aquifer and soil permeability characteristics relative to the subsurface geological formation's ability to accept and move the additional water discharged from the effluent disposal system.

Based on historic soil data from the original septic system testing, as confirmed by mapping, the site includes coarse glacial stratified deposits that were bisected by a geological formation that consisted of shallow depth to bedrock overlaid by a dense glacial till in certain locations. (Figure 1, from the Hydrogeological Site Assessment Report[1] submitted to MassDEP in support of the BRP WP 83 [Bureau of Resource Protection Water Pollutant hydrogeologic evaluation] Application.) Given that the more pervious coarse-stratified deposits were along the edge of Pine Lake and along the property boundary, the most logical location to complete further site investigations was along the property line, in the location of a large (abandoned) original septic system, where the previous owner was aware that this location did, in fact, consist of highly permeable sand and gravel deposits.

Using this information, soil test pits and perc tests were completed and witnessed by MassDEP. The

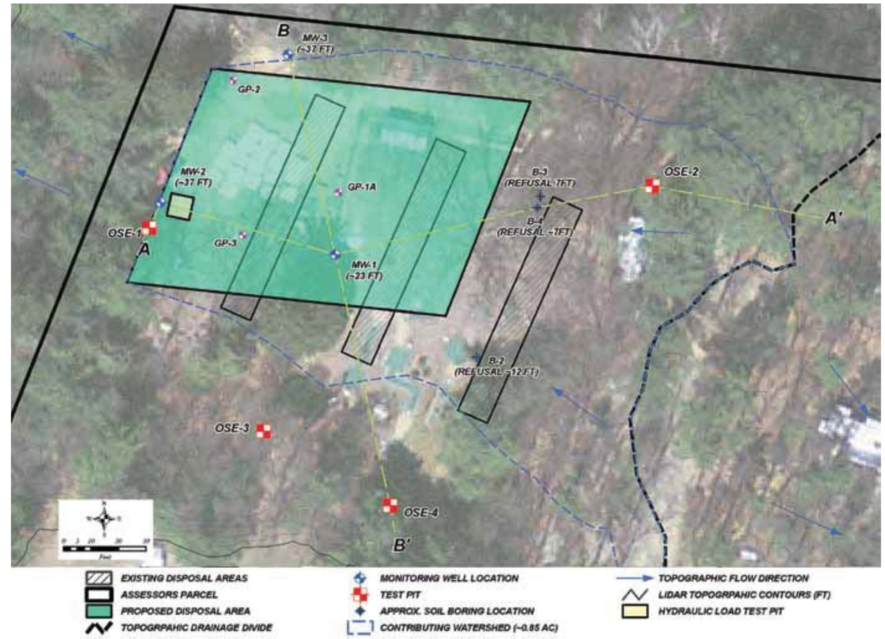

Figure 2. The site was investigated via borings, monitoring wells, and groundwater conductivity testing

process helped to determine estimated seasonal high groundwater (ESHGW) levels, depth to impervious layers or bedrock, and perc test rates to be used in defining the proposed effluent disposal system's LTAR. To complete this work, a series of test pits was excavated to depths of up to 13 ft (3.96 m) with no refusal observed, and the materials encountered ranged from fine to medium sand with pockets of medium to coarse sand. No groundwater or evidence of ESHGW was observed. Perc tests conducted in this area resulted in a rate of less than 2 minutes per in. (mpi) (0.79 min/cm) of water drop in the perc test hole. Given that the soil testing revealed a Class I soil (sands and gravel) and the perc rate was less than 5 mpi (1.97 min/cm), the MassDEP "Guidelines for the Design, Construction, Operation and Maintenance of Small Sewage Treatment Facilities with Land Disposal" (Guidelines)[2] allow for a LTAR up to 3 gpd/ft^2 (122 L/d/m^2) of effluent to leaching area when leaching chambers that are configured in a trench format are used.

Given the high LTAR determined during soil testing, this area of the site was worthy of further investigation and study via borings, monitoring wells, and groundwater conductivity testing. Initially, three 2 in. (5 cm) diameter monitoring wells (MWs 1, 2, and 3) and three soil borings (GP-1A, GP-2, and GP-3) were completed using a hollow stem auger drilling rig, with split spoon samples collected at 5 ft (1.5 m) intervals. (Figure 2, from the Hydrogeological Site Assessment Report[1].) The borings were advanced using a track-mounted hollow stem auger drilling rig and the monitoring wells were completed with 15 ft (4.6 m) of 0.010-in. (0.254 mm) slot screens, filter pack, and bentonite. Materials encountered near the proposed groundwater discharge were glacial outwash deposits consisting of fine to medium sand with some silt.

At monitoring well MW-1, near the center of the existing and proposed disposal areas, the outwash deposits were underlain by a basal till deposit at a depth of approximately 21 ft (6.4 m) and bedrock at a depth of approximately 23 ft (7.0 m). A second round of soil borings (B-2, B-3, and B-4), approximately 75 ft (23 m) east of MW-1, encountered similar unconsolidated deposits and refusal at depths ranging from 7 to 12 ft (2.1 to 3.7 m). Monitoring well MW-2 (~80 ft [24 m] west of MW-1) and monitoring well MW-3 (~ 90 ft [27 m] north-northwest of MW-1) were both advanced to depths of 37 ft (11.3 m) and both encountered a layer of clay and silt at depths of approximately 36 ft (11 m), at which point drilling was terminated. No groundwater was observed during the monitoring well installation. Soil mottling, which is evidence of ESHGW, was observed at monitoring well MW-1 at a depth of approximately 16 ft (5 m) and at monitoring well MW-2 at a depth of 12 ft (3.6 m). Depths to refusal observed at the site suggest that the bedrock surface slopes steeply to the west, which was anticipated based on the surficial geology and bedrock mapping reviewed.

Because the testing program revealed a deep layer of impervious soils in MWs 2 and 3 and no groundwater was in the upper sands and gravel layers, traditional slug testing or pump tests to determine conductivity could not be completed. To adjust the plan, a first round of testing was performed using *in situ* vadose zone borehole permeability tests in borings GP-1A, GP-2, and GP-3. These tests use the method described by Reynolds and Elrick (1985)[3] and were done using a Guelph Permeameter, which works on the Mariotte principle and measures the steady-state rate of water recharge into unsaturated soil from a cylindrical hole of constant water depth. Using this method, the calculated permeability of the unconsolidated deposits at the site ranged from 45.0 to 56.7 ft/day (13.7 to 17.3 m/d) with an average value of 50.9 ft/day (15.5 m/d).

As this testing was completed in an unsaturated highly permeable soil, a second test to further assess the viability of the proposed effluent disposal site was conducted. A small-scale hydraulic load test was configured and run at the site to measure conductivities at a known discharge rate, which would then be able to be scaled to the full discharge in the mounding model calculations.

This testing was completed with a six-day hydraulic loading test. To complete this work, a 10 ft by 10 ft (3 m by 3 m) pit with a depth of 3 ft (0.9 m) was excavated approximately 2.5 ft (0.76 m) east of MW-2 and then backfilled with non-native permeable sand. A garden hose outfitted with a totalizing flow meter and rotometer-type direct read flow meter was directed to the pit and set to a constant discharge rate of 2 gpm (7.6 L/m). Given this flow and the area of the pit, this corresponds to a loading rate of approximately 28.8 gpd/ft^2 (1,173 L/d/m^2). Based on the runtimes recorded during the six-day test, approximately 9,036 gal (34,205 L) were discharged to the pit. At no point during the test was water detected in MW-2, and during that time the pit did not overflow. Since the well screen for monitoring well MW-2 was constructed just above the clay layer observed at approximately 36 ft (11 m) below ground surface, the fact that no water accumulated beneath the pit suggests the unconsolidated deposits were highly permeable and that the clay layer may not be continuous, most likely resulting in recharge to deeper portions of the aquifer.

Based on this approach and the data obtained, sufficient information was available to prepare a full-scale analysis of the proposed groundwater discharge of treated effluent. An analytical groundwater mounding model, using proprietary mounding software, was run for this analysis. The software was used to simulate the leaching areas' actual sizes, orientations, and loading rates in the aquifer, assuming a uniform thickness, permeability, and specific yield. Based on the MassDEP LTAR of 3.0 gpd/ft^2 (122 L/d/m^2) and the maximum Title 5 discharge of 31,050 gpd (118,000 L/d), a leaching area using plastic leaching chambers installed in a trench format was laid out and required a footprint of approximately 14,000 ft^2 (140 by 100 ft) (1,301 m^2 [42.7 by 30.5 m]). As required in the Guidelines, treated wastewater flows of 80 percent of the Title 5-based flow rate (31,050 gpd x 80%) = 24,840 gpd ([118,000 L/d x 80%] = 94,000 L/d) is the loading rate used in the groundwater mounding analysis. This discharge, over the proposed leaching area, results in an actual loading rate of 1.77 gpd/ft^2 (72 L/d m^2). As required, the model simulation of the discharge was done over 90 days in an aquifer with a specific yield of 0.30. Based on these input parameters, the maximum predicted groundwater mound at the center of the discharge was estimated to be approximately 1.8 ft (0.55 m).

These results indicate that the effluent disposal area proposed for this site was, in fact, suitable at the proposed discharge of 31,050 gpd (118,000 L/d) and that the site could accommodate this size discharge and not affect any environmentally sensitive receptors, such as Pine Lake or any nearby water supply wells. Because of the presence of the surficial geological divide, it also appears as if the proposed discharge location is within an aquifer that does not direct groundwater toward Pine Lake or the associated wetlands and stream, thereby allowing for that impaired waterbody to begin to restore itself once the existing septic system discharges located within that area were taken offline. In addition, there are no public water supply wells or MassDEP-defined sensitive receptors (such as priority habitats for rare species or certified vernal pools) within ½ mi (0.8 km) of the proposed discharge in the down-gradient groundwater flow direction and only one private water supply well within ⅓ of a mi (0.53 km) of the discharge. Given the high level of treatment anticipated from the WRRF, the presence of a single private water supply well, when such wells are allowed to be located at least 100 ft (30.5 m) from a septic system discharge, was determined to be of little concern by MassDEP.

SEWAGE COLLECTION SYSTEM AND WRRF

The sewage collection system at the site was a reconstruction of the existing system and used novel approaches to collect RV wastewater. A custom RV sewer connection station was designed and built at each RV pad so that when customers pull in with their RV, there is a dedicated connection point for their waste tank discharge hose in the proper location (based on typical RV configurations) that consists of a specialized 4 in. (10 cm) PVC RV connection port. Each pad also allows the guest to connect into the resort's potable water and electric systems, which are part of the upscale amenities. For the sites that have trailer cottages, permanent gravity building sewer connections were designed and constructed based on a modular home sewer connection configuration.

Given the topography of the site, where the lowest areas are adjacent to Pine Lake, and a ridge high point runs east–west through the middle of the parcel, the sewer system was divided into three main sections: the upper section, connecting directly into the WRRF sewer system; the main lift station, collecting most of the sewage from the down gradient side of the ridgeline, and the area around the main amenity buildings, which has a dedicated pump system that feeds into the main lift station. The lift stations were configured with submersible duplex pump systems in precast concrete wet wells. This configuration was set up to minimize sewer lengths and depths to maximize collection efficacy by reducing sewage pipe residence time. The raw sewage is directed to the WRRF location where it flows via gravity into the first unit process tank.

Table 1. Influent and effluent water quality aspects

Parameter	Typical RV park influent values	Target effluent values	GWDP permit limits
Total Biochemical Oxygen Demand (BOD)	400 mg/L	<25 mg/L	30 mg/L
Total Suspended Solids (TSS)	300 mg/L	<25 mg/L	30 mg/L
Total Nitrogen (as Nitrogen)	65 mg/L	<10 mg/L	10 mg/L
Nitrate-Nitrogen	N/A	<10 mg/L	10 mg/L
Ammonia-Nitrogen (as Nitrogen)	55 mg/L	1 mg/L	N/A
pH (standard units)	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5
Dissolved Oxygen	N/A	5.0 mg/L	N/A
Oil and Grease	N/A	<15 mg/L	15 mg/L
Temperature	55 F (12.8 C)	N/A	N/A
Alkalinity	275 mg/l	N/A	N/A

The WRRF at Pine Lake, approved under the Massachusetts General GWDP Program, combines advanced aerobic and anoxic biological processes with filtration to accomplish treatment, and therefore produces an effluent far superior to that of the previously used subsurface sewage disposal systems. In addition to the need to provide tertiary level treatment commensurate with MassDEP's General GWDP, the seasonal nature of this site and use also presented unusual challenges in maintaining a biological population during low seasonal flows. Based on these metrics, a pre-packaged advanced biological treatment system was determined to be the most cost-effective and operationally flexible system for this project.

The proprietary treatment system uses a combination anoxic/flow equalization reactor to settle coarse solids and equalize diurnal flows, followed by two fixed sand/media bed systems or biological aerated filters (BAFs) that are operated in both aerobic and anoxic environments to biologically treat and filter the sewage from the site. This system can produce a high-quality effluent while operating over a wide range of hydraulic and organic loadings. The biological growth providing waste treatment develops in response to the imparted load and the very high concentration of organisms within the reactors because of the nature of the interstitial space within the sand/media bed reactors. During periods of low hydraulic or organic loading, the biological growth is concentrated and maintained within the reactor by adjusting the frequency of filter backwashes. However, as the flow (or organic load) is increased, the organisms begin to proliferate, and a larger percentage can remain in the system and be used for high levels of treatment.

This was a critical consideration/design feature for this site because, as one can imagine, the peak flows and loading from the summer vacation season are orders of magnitude greater than the low flows during winter and, depending on the weather, etc., the RV resort could even shut down for a period during the coldest months of the year. For this site and project, the WRRF system has to maintain a base biological population under low or no flow conditions and quickly ramp back up to achieve treatment when the flows increase during the spring heading into peak summer vacation season. With a combination of low flow operational settings and recycle pathways, the Pine Lake WRRF has operated well across these wide fluctuations in seasonal flows to the facility.

In addition to removing organic matter, the treatment system was designed to oxidize influent nitrogen, typically present as ammonia–nitrogen and organic nitrogen forms in raw sewage, converting it to nitrate–nitrogen. Once fully oxidized, the nitrate–nitrogen is converted to nitrogen gas via anoxic denitrification. The anoxic reactor is a constantly submerged sand media bed that creates the necessary anoxic environment for final denitrification. Once complete, this process releases nitrogen to the atmosphere as nitrogen gas, enabling the treatment facility to comply with the stringent GWDP total nitrogen and nitrate–nitrogen limitations shown in Table 1.

RV RESORT WASTEWATER TREATMENT

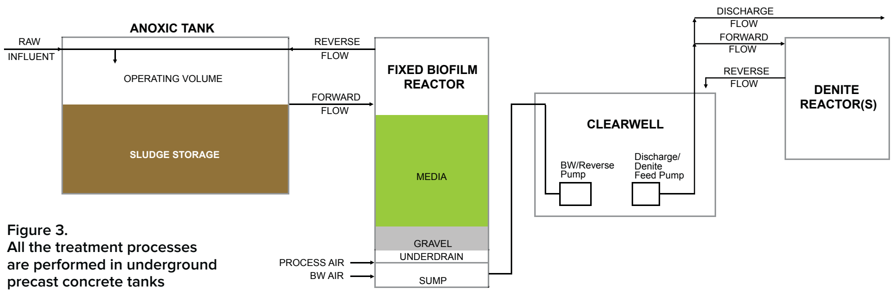

Figure 3.
All the treatment processes are performed in underground precast concrete tanks

As shown in Figure 3, taken from the MassDEP Permit Application Engineering Report, all the treatment processes are performed in underground precast concrete tanks of varying sizes and depths, allowing for a small, unobtrusive footprint for the system. This was also a critical design consideration because, as is often the case with GWDP systems, they are typically sited in and around public areas, whether it be residential apartments, office buildings or, as in the case of Pine Lake, a vacation resort.

As previously noted, the WRRF system uses a modified fixed-film suspended growth batch process, and the sizing of each unit process and the required treatment equipment was completed using standard biological treatment process kinetic calculations as well as the design standards in both Technical Release 16 (TR-16) "Guides for the Design of Wastewater Treatment Works" published by NEIWPCC[4], and the MassDEP design Guidelines[2]. Since the Pine Lake site will receive very different warm and cold weather flows, design kinetics for both scenarios were run in a biological modeling software program, with winter conditions the governing factor in the design, particularly for denitrification. As shown in Figure 4 (this facility's block process flow diagram[5]), the proprietary batch process is configured to perform up to six passes, or batches, per day through the main reactor, which functions as both an up and down flow reactor bed and is operated both in the presence of, and with the absence of, oxygen to simultaneously encourage aerobic CBOD removal and nitrification/denitrification.

In case nitrate–nitrogen and/or aeration levels in the main reactor are such that full denitrification does not occur before the batch process is complete, a dedicated anoxic (denitrification) reactor was included in the design and also runs in a batch configuration. The operator adjusts the batching sequence of this reactor, whereby any remaining nitrates are passed through the anoxic media bed while a commercial supplemental carbon source is added to encourage final denitrification to permit limits or below.

Once final treatment is complete, the treated effluent is stored in the effluent dosing chamber where it is periodically (up to eight doses per day at full design flow) dispersed into the effluent disposal system, which as noted previously consists of plastic infiltration chambers in a trench format. The system for Pine Lake is sized for the peak day flow of 31,050 gal (118,000 L) spread out over eight doses per day, resulting in each dose being 3,881 gal (14,691 L). The effluent is pumped into a large 14-outlet distribution box, which evenly distributes the flow to each chamber trench, with each trench receiving 277 gal (1049 L) from each dose. The 14 trenches are each 100 ft (30.48 m) long and have a 4 in. (10 cm) Schedule 40 PVC perforated pipe installed along the entire length of the trench, ensuring equal and proper distribution over the leaching area from each effluent dose.

DISCUSSION

As shown herein, suburban and rural areas that do not have access to municipal sewer systems must employ alternative methods of sewage treatment and disposal beyond the traditional septic system for the scale of developments often required in today's economic climate to be viable. This concept is especially applicable to the redevelopment of campground sites, as they are usually in rural areas, away from any public sewer infrastructure and often served by old, out-of-code septic systems. Pine Lake RV Resort demonstrates what can be achieved when a cost–benefit analysis method is used to identify the optimum size of this style of resort relative to the cost of private WRRF systems to support that development program. As the process clearly showed, absent an available connection to public sewer, these redevelopment projects must be sized well beyond the limits supported by traditional (septic system) means of on-site sewage disposal and therefore must be cost-effective while factoring in tertiary levels of wastewater treatment at the site.

Through the MassDEP GWDP regulations and program, there is a well-defined system and process

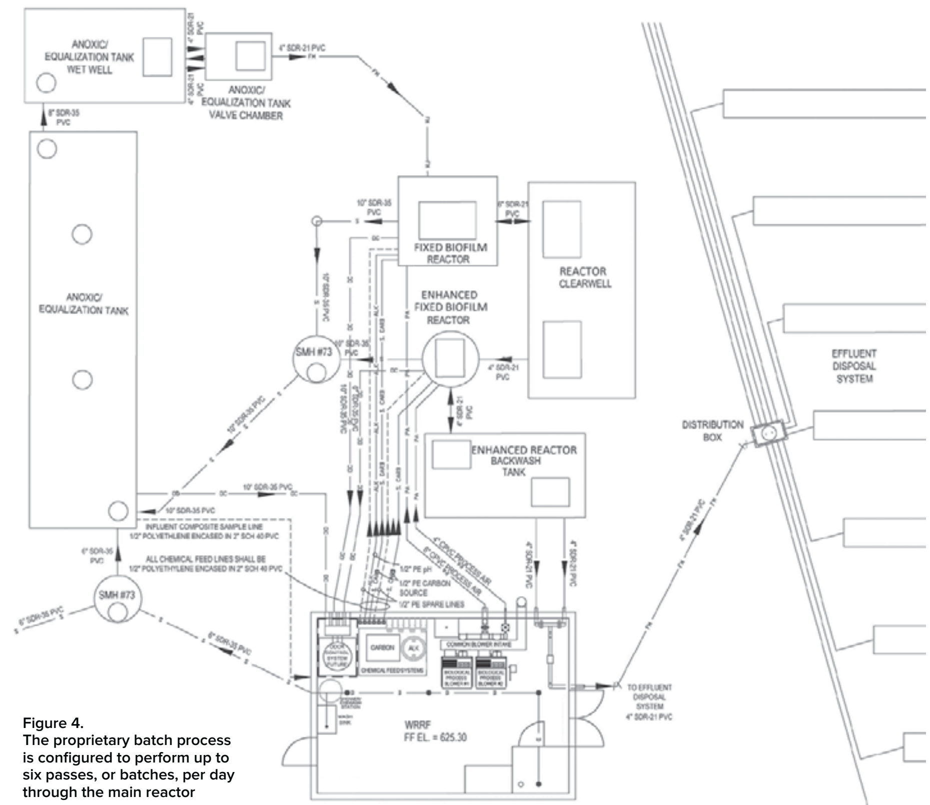

Figure 4.
The proprietary batch process is configured to perform up to six passes, or batches, per day through the main reactor

for the necessary site evaluations, design, permitting, and operation of these types of facilities. While the flows and loadings may seem minor compared to a multi-mgd municipal facility, the sophistication necessary to complete the feasibility analyses for site approvals as well as to achieve the level of treatment required are often more robust that what is typically permitted at larger facilities. While this process can seem both daunting and burdensome for a project of this size, it is important to note that, since the inception of the GWDP regulations some 40 years ago, this industry has greatly matured and the many available technologies and systems can make these decentralized WRRFs cost-effective to design, build, and operate. Over the past 40 years that this program has been in effect, over 1,000 of these systems have been permitted and/or are in use in Massachusetts, many similar in size and type as the Pine Lake WRRF.

CONCLUSIONS

As land development and land reuse changes over time in Massachusetts, it has become ever more important that sites that have been developed are "repurposed" to encourage new housing and recreational uses in suburban and rural areas, while at the same time not requiring the expensive and often controversial expansion of municipal sewer systems. Although there can be an economy of scale with large centralized sewage collection and treatment, the updated science has shown us it is important to limit the amount of water transferred between major basins. To protect low-flow streams, rivers, and sensitive aquifers, efforts must be made to avoid withdrawing groundwater from one basin as drinking water and feeding it into another basin via a surface-water wastewater discharge from a centralized sewage treatment plant.

The size and scale of development required today cannot be supported via on-site septic systems while also protecting public health and the environment, and centralized sewer capacity is not (and will not be) coming to these suburban and rural areas. As such, private decentralized on-site wastewater collection, treatment, and subsurface effluent disposal systems are pivotal in the continued redevelopment of underused and abandoned properties throughout suburban and rural Massachusetts. As more and more GWDPs are issued, development companies are becoming more comfortable with these systems and how they can be effective in redeveloping parcels. Furthermore, as technologies and automation improve and systems continue to become smaller and more efficient, the process is becoming more cost-effective at lower aggregate flows, thereby further providing options for these types of systems in many other types of development and redevelopment projects.

The new Pine Lake RV Resort was born out of a developer's desire to preserve a historic campground site while also providing a new style of camping vacation to an underserved population in Massachusetts. Without the expertise and mechanisms available to cost-effectively allow for the design, permitting, building, and operation of a small privately funded and owned decentralized wastewater treatment facility, these revitalization stories would be few and far between and redevelopment would continue to be concentrated in urban areas, further exacerbating the urban–suburban imbalances that exist.

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ABOUT THE AUTHOR

David Formato is the founding principal engineer of Onsite Engineering, Inc., and has over 25 years of experience in the design, permitting, evaluation, and compliance monitoring of decentralized groundwater discharge wastewater treatment and disposal systems.

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