V. Wastewater Collection and Treatment Recommend Improvements

A. Conventional Collection, Conveyance, Treatment and Discharge

1) Wastewater Treatment Plant Expansions and Upgrade

The Lynn Township Sewer Authority's wastewater system will continue to serve all of the residents and businesses of New Tripoli and its surrounding area.

Chapter 3 evaluated each treatment stage in the existing facility in detail, identifying its capacity and problems. Several of the existing features in the current facility can continue to be used in their present form, and several others can be converted to new uses. This Plan is founded on the Township's desire to maximize the reuse of the existing facilities.

This Plan proposes to increase the design capacity of the treatment facility to an average daily flow of 160,000 gallons per day or 640 EDU's. For the purposes of this study, it is assumed that each EDU would produce an average daily flow (ADF) of 250 gpd. While the majority of the existing individual treatment stages have adequate capacity for the permitted flow of 80,000 gallons per day, none are large enough to handle double the flows. Such flows currently occur during storms, and flows will increase as growth occurs within the township and there are more hookups into the facility.

Recent concerns with pollutant loadings in the Chesapeake Bay has prompted the PaDEP to require facilities to lower effluent pollutant limits to those seen in table V-1. Concerns are being raised in the Delaware Bay Watershed as well, which may prompt PaDEP to adopt similar effluent limitations to those seen in facilities residing within the Chesapeake Bay Watershed. These are moderate nutrient limitations that can be easily achieved.

Table V-1
PaDEP Effluent Limitations for Reduction of Pollutants to the Chesapeake Bay

Pollutant	30-Day Average Concentration, mg/l
Total Nitrogen (TN)	10.0
Total Phosphorus (TP)	2.0

The plant would be upgraded as described below to achieve these advanced secondary effluent limits utilizing an activated sludge treatment process:

- The raw wastewater would be screened to remove coarse organics, floatables, and large solids before dumping into an influent pump station. A new mechanical screen would replace the comminutor.
- The pump station would lift screened wastewater into the existing aeration tanks that will be modified depending on the process selected.
- An optional process would be to pump the screened wastewater through a pressurized grit removal system prior to the activated sludge tanks.
- One flow distribution box would provide an exactly equal flow split into each of the two biological reactors, and then another would distribute the reactor effluent proportionately to two secondary clarifiers.

- The existing aeration tanks would be converted into biological reactors for either the VLR process or the VIP process, which would have a step-feed alternative to improve effluent quality during peak flows. These processes have air diffusers, mixers and other specialized equipment that would be needed.
- New aeration blowers would be needed for the reactors and aerobic digesters.
- A new, larger secondary clarifier would be added to provide redundancy and enough capacity to treat peak flows.
- The parshall flume would be replaced because a larger flume would be needed to handle the increased flows.
- An ultraviolet light disinfection system would replace the chlorine contact tanks.
- A cascade aerator could be added if needed to boost the effluent dissolved oxygen levels prior to reaching Ontelaunee Creek.
- Return/waste sludge pumps would be set in the control building, near the existing pumps.
- A scum storage manhole could be built to keep it separate from the main process, or scum could be discharged to the reed beds.
- New aerobic digesters would be built.
- The current building will be utilized to house the electrical power supply and controls and the aeration blowers.
- A new, much larger emergency generator would be needed to replace the existing.
- The option of replacing the reed sludge drying beds with a belt filter press as been presented. Either additional drying beds, or the press, would be needed.

A wide variety of nutrient removal processes are capable of meeting the nutrient limits considered in this evaluation. The Author has employed at least eight, many in multiple installations. We evaluated two alternatives, the plug-flow process best suited for these limits and operating conditions, and the Vertical Loop Reactor, recommended in the previous Act 537 Plan that was rejected by PADEP (but not because of the VLR):

1) The **Virginia Initiative Plant (VIP) Process**,

   The VIP is a modification of the activated sludge treatment process. The VIP Process would achieve the above limits strictly through biological action, a process known as Biological Nutrient Removal (BNR) because nitrogen and phosphorus are removed biologically. Nitrogen and phosphorus are two key nutrients that impact algae growth in slow-moving waters, particularly estuaries such as the Delaware Bay. Only capital costs are presented below; the present worth cost comparison follows in Chapter VI.

2) **Th**e **Vertical Loop Reactor (VLR) process**

   Many of the treatment plant modifications would be the same for both alternatives. The following reviews these two options. The plants were evaluated using similar treatment stages, materials of construction, and auxiliary equipment to make the comparison as fair and relevant as possible. Only capital costs are presented below; the present worth cost comparison follows in Chapter VI.

The following describes the individual treatment processes in greater detail:

a. Influent Screens:

There are many types of mechanical screens and the selection depends in large part upon the type of equipment downstream that screenings would damage or require more maintenance. The finer the screen, the more material it removes, but also the more maintenance it requires. A coarse screen such as a bar rack or a climber screen was commonly matched with trickling filters or older activated sludge plants such as extended air. With coarse bubble or surface aerators fouling by rags was not a major problem. Fine mesh filter screens are well suited for nutrient removal processes that employ anoxic zone mixers, internal recycle pumps and fine-bubble air diffusers. They will minimize propeller fouling and pump plugging. Ultra-fine perforated plate screens are now in vogue because they are necessary with membrane treatment, integrated fixed-film activated sludge, and other enhanced nutrient removal processes.

For both alternatives, a fine mesh rotating filter screen is proposed to replace the comminutor as the first treatment stage. While a comminutor reduces the size of rags, floatables, and other large objectionable material, it does not actually remove them from the wastewater. The fine screen is appropriate to protect pumps and membrane air diffusers.

The fine mesh filter screen is a type of continuously self-cleaning screen. The screen is set in the channel at an angle facing the incoming wastewater, which passes through the screen. Large and medium sized particles are trapped on the screen. They remain on the screen and are washed by the wastewater as it passes, and by jets set at the top of the screen and inside the conveyor, so most of the organic material will be broken down into smaller particles that will pass through the screen. In this manner, a large part of the odorous organic materials are retained in the wastewater. The screen also works as a conveyor that lifts the screenings out of the water as it rotates and deposits them into a dumpster for removal to a landfill.

The screen is constructed entirely of stainless steel and plastic so it does not corrode. A small motor rotates the screen, which would be set in the existing concrete channel and extend up to ground level. A manually cleaned bar screen would be provided so the wastewater can continue to be screened even when the drum is being serviced. The screen would be set on a pivot so it could simply be rotated out of the channel for servicing. Optional equipment includes a bagger to wrap the screenings as they come out, significantly reducing odors.

b. Influent Pump Station:

The existing influent pump station consists of an open wetwell constructed as part of the same structure as the flow meter channel and the comminutor. Submersible pumps are set inside the wetwell, and they pump up into the biological reactors. Expanding the plant would involve adding treatment stages and flow distribution boxes that would increase the head loss somewhat. If grit removal were added, the high water level in it would be several feet higher than in the reactors. The pumps are old and dated, and due for replacement.

The pump station would be set downstream of the screen, which would protect the pumps from large objects such as sticks and rags that could damage the pumps. The wetwell stores the wastewater, allowing the pumps to cycle on and off. Level sensors would control the pump operation, turning them on when the wetwell is full and allowing them to drain the tank to a preset level. Submersible pumps would be mounted on guiderails so they could be easily lifted and removed for service.

The overwhelming majority of Lynn Township's wastewater collection system is PVC (polyvinyl chloride) pipe installed in the late 1970's. The PVC pipe has been furnished with flexible rubber seals similar to those used on concrete, and iron pipe.

The very high peaking factor in the raw wastewater flow rate is indicative of a serious leakage problem, one that is very unusual for a mostly PVC collection system. In the year 2006, the maximum daily flow recorded was 207,000 and the annual daily average was 80,000 gallons. Dividing the peak flow value by the average flow value yields a peaking factor of 2.5, which is high. Recently, with the installation of a new flow meter capable of reading higher daily flows, a maximum daily flow of 600,000 gallons per day was recorded. Using the average daily flow of 80,000 gallons from the year 2006, this new flow gives the facility a peaking factor of 7.5, which is extremely high. By comparison, properly constructed newer systems, with PVC or ductile iron pipes and precast concrete manholes, have peaking factors well below 2.0 (although 2.0 is used for design purposes).

Influent pump stations must have sufficient capacity to pump the peak incoming flow with the largest pump out of service. The influent pump station would be a submersible station with four variable speed pumps installed. Three would provide the peak flow capacity of 600,000 gpd, while the fourth would be an installed spare. Because of the wide variation in flow one of the pumps would have half the capacity of the others.

c. Grit Removal: Optional for both alternatives

The existing treatment plant does not have a grit removal system, which is not unusual for a plant this size. Grit refers to sand and gravel, but most grit is very fine sand. It is of concern because of the wear it causes to treatment plant equipment: pumps, pipes, mixers, air diffusers, etc. The expanded plant would be at the size where grit removal is considered, especially with the leaking collection system problems. Sewers with high peaking factors carry greater grit loads, as the soil surrounding the sewer washes into the system through a crack or hole during storms. As an example, Millville, Columbia County, receives a very similar average flow to what Lynn does, an average of about a cubic yard of grit is removed every month, with 98% coming during wet weather. The grit system would cost roughly the same as the mechanical filter screen. If Lynn Township considers grit removal as part of the expansion, the cost should be weighed against the operational savings.

A pressurized vortex grit removal system would be recommended for Lynn Township if it chooses to have one installed. The grit chamber would be covered, so odors cannot escape from it. The cover can be removed for operator access, but that is normally required only quarterly for inspection. The grit removal system relies entirely on hydraulics of the pumped flow to create a vortex that forces the grit to settle in the bottom. An eductor connected to the bottom pulls the settled grit out of the bottom.

d. Reactor Influent Flow Distribution:

Currently, raw wastewater is piped from the influent pumps to the two aeration tanks and a simple tee in the piping splits the flow. The split is never even due to subtle differences in the hydraulics that depend on the flow rate and this causes the two aeration tanks to operate differently because they do not receive the same feed. This operational difficulty cannot continue once the plant is upgraded.

Influent to the reactor should be fed to a reactor influent distribution box that is equipped with weir gates, which are the most reliable means to evenly distribute flow. Influent flows over top of the weir and if the gates are at the same elevation, the flow is evenly split. Raise one gate high enough and all flow goes to the other reactor, so the first can be drained for service.

e. Activated Sludge Biological Reactors:

According to the Lynn Township Sewer Authority Wastewater Treatment System Expansion/Upgrading Feasibility Study dated September 2006 pages 3-1 to 3-2, preliminary effluents for this facility were requested from the PaDEP. According to this report, a reply from PaDEP was received on July 2, 2005 stating: … barring any regulatory changes or other unforeseen circumstances, the effluent limits for this proposed discharge should be identical to the Lynn Township Sewer Authority's NPDES Permit No. PA0070254. The NPDES Permit Limits are as follows:

Table V-2
Effluent Limits for Lynn Township WWTP

Effluent Limits for Lynn Township WWTP
NPDES Permit No. PA0070254

Parameter	Monthly Average (mg/L)	Instantaneous Maximum mg/l)
CBOD5 (5/1 to 10/31)	15	30
CBOD5 (11/1 to 4/30)	25	50
Total Suspended Solids	30	60
NH3 (5/1 to 10/31)	4	8
NH3 (11/1 to 4/30)	12	24
Dissolved Oxygen	minimum of 5.0 mg/l at all times	
Fecal Coliform (5/1 to 10/31)	200/100 m/L as a geometric mean	
Fecal Coliform (11/1 to 4/30)	2,000/100 mL as a geometric mean	
pH	6.0 to 9.0 standard units at all times	
Total Residual Chlorine	0.3	0.7

Activated sludge is so named because the aeration basins contain a biomass of bacteria, viruses, protozoa, and microorganisms that are called activated sludge. These microorganisms consume the pollutants in the raw wastewater, and use it as food to live and reproduce. They require oxygen, so the tanks are aerated. The activated sludge biomass contains many more microorganisms (1,800 to 4,000 mg/l) than the raw wastewater does (normally 100 to 300 mg/l). These microorganisms are readily found in nature, but an artificially high concentration is maintained in wastewater treatment plants. Clarifiers or setting tanks follow the aeration basins or settling tanks, where the biomass settles and separates from the clarified effluent, which overflows the weirs and exits the activated sludge process.

Nitrification: Most activated sludge plants undergo seasonal nitrification, because when the wastewater is warm enough (65^{o} F or more) nitrification is unavoidable unless very high food to microorganism (F:M) ratios are used. Nitrification creates additional alkalinity and oxygen demands over BOD removal. It also results in a poor-settling sludge, because the low F:M ratios required promote the growth of filamentous organisms. For these reasons the Manual's secondary clarifier guidelines require lower loadings for nitrifying systems than for BOD removal alone.

Another problem is that partial nitrification is an inherently unstable process, with wide fluctuations in effluent ammonia nitrogen levels. Ammonia creates a chlorine demand on top of what is needed to disinfect the wastewater. The fluctuating ammonia levels from partial nitrification vary the chlorine demand, and so the effluent chlorine concentrations can range from zero to above the permit limits. As the chlorine levels change during partial nitrification, the disinfection can also change, and if the chlorine concentrations are low for too long, coliform bacteria violations can result.

Last, nitrification consumes alkalinity at a rate of 7.1 parts of alkalinity for every part of ammonia nitrified. While alkalinity is not an effluent permit requirement, it is necessary to create a stable wastewater. If alkalinity is too low, the pH levels can drop, possibly below the 6.0 required by the permit.

The treatment process proposed for Lynn Township should minimize the problems associated with the partial nitrification that will occur in late summer months. Both alternatives would include an anoxic zone. The anoxic zone will help to recover alkalinity, lower oxygen demand, and provide a better settling sludge. Because the "aeration" tanks would include unaerated (anoxic) conditions, the term 'biological reactors' is used to more accurately describe their configuration.

1) *Anoxic conditions:* Each reactor would contain one or more segments where anoxic conditions occur. This volume would be mixed, but it would not be aerated. The BOD in the raw wastewater would serve as the carbon source (food) for the microorganisms (bugs). The return sludge would provide nitrites and nitrates ($NO_{x)}$. Without an air supply, any dissolved oxygen is quickly consumed and the mixed liquor becomes anoxic, where the only available oxygen present is bound up in the NO_x. Certain microorganisms can use this oxygen to consume some of the BOD (typically 20-30%). This reduces the overall oxygen demand, lowering power consumption correspondingly. Those microorganisms happen to settle better than the filamentous organisms that nitrification helps to grow, so pre-denitrification produces a better settling sludge. Last, denitrification releases alkalinity back into solution, at a rate of 2.8-mg/l of alkalinity for every 1.0-mg/l of nitrate-nitrogen reduced. While this alkalinity credit is far less than the alkalinity consumed by nitrification, it reduces the pH problems experienced by nitrifying WWTP's.

2) *Oxic Conditions:* Each reactor would contain one or more aerated segments where oxic conditions occur. Wastewater would be nitrified and BOD would be consumed in the oxic portion, which is configured differently for each process. The existing aeration tanks are 100% under oxic conditions, with both having just a single large, completely mixed oxic zone.

I. Virginia Initiative Plant (VIP) Biological Reactors:

Generally, the ideal treatment process to upgrade the existing aeration tanks into reactors capable of treating the wastewater and removing nutrients is the process that best utilizes the existing tank volume and layout. Additionally, this process should also be able to achieve the effluent limits of 10 mg/L and 2.0 mg/L Total Phosphorus easily without increasing the reactor volume and with minimal modifications to the existing tanks.

Currently, there are two aeration tanks, each 34 feet long. The three existing sludge-holding tanks will be modified to include as part of the VIP process. The two holding tanks that were originally clarifiers are each 9 feet long, while the original holding tank is 8 feet long. Aeration and sludge holding tanks are all 15 feet wide and 12 feet high with a water depth of 10.5 feet. The combined volume of the two reactors plus the three holding tanks is 14,800 cubic feet or 111,000 gallons. The hydraulic detention time at a design ADF of 160,000 gpd would be 16.6 hours, more than enough for a plug-flow NRT process, so the walls would not need to be raised.

Plug-flow treatment processes are ideally suited to the existing rectangular tanks. Plug-flow describes a process where influent wastewater and all recycle streams (return sludge, internal recycles, etc. are introduced at one end of the reactor and they flow as a "plug" down the length of the reactor, exiting at the other end. The combined streams flow together along the tank, like a bullet down a barrel. Plug-flow processes produce better effluent quality than complete-mixed tanks for a given volume because they operate at higher kinetic rates. This is because all of the food in the raw wastewater is mixed with a relatively small amount of mixed liquor at the head of the plant so the reaction rate is not limited by the amount of food.

The VIP reactors are a type of activated sludge biological reactor that consists of relatively long, narrow concrete vessels that have the influent fed at one end and the effluent flowing out of the other. The VIP was patented by a Virginia Tech processor who disliked the patenting of treatment processes and millions of dollars of royalties being collected. He released the VIP into the public domain, meaning it could be used without charge. The Author has three VIP plants in operation and another under design.

The VIP process has been operating at multiple other facilities for a number of years, consistently reducing nutrients to well below the levels required here. The VIP reactors would be segregated into (in order) anaerobic, anoxic, and oxic zones. Only the oxic would be aerated. The reactors would have two internal recycle pumping systems; the mixed liquor and nitrate recycle pumps.

Mixed liquor from the VIP reactors would pass onto the secondary clarifiers, where the sludge would separate from the clarified effluent, which would then overflow to the UV disinfection system. Pumps would return settled sludge from the bottom of the secondary clarifiers to the reactors. Aeration blowers would pump air into the reactors through fine bubble diffusers to keep the microorganisms alive.

a. *Modifications:* Baffle walls would be built across the width of the aeration tanks to divide them into zones and subzones. They would cover 98% of the tanks' cross-section, with a small opening at the bottom plus the top of the wall would be just below the water surface. Mixers would maintain solids in suspension in unaerated (anoxic or anaerobic) zones. Fine bubble diffusers would replace the coarse bubble. Internal recycle pumps would convey mixed liquor from one part of the reactor to the other. The secondary clarifier would continue to be used, along with the return sludge pumps. A second, larger clarifier would be added. The peak flow bypass mentioned earlier should be incorporated to maximize the plant's peak flow treatment capacity.

b. *Anaerobic Zone:* Both reactors would contain an anaerobic zone. The zone would be mixed, but it would not be aerated. The influent pumps would feed raw wastewater to the anaerobic zone. Denitrified mixed liquor would be pumped from the end of the first anoxic subzone (where nitrates are lowest) to the head of the anaerobic zone. The high oxygen demand of the mixed liquor would quickly consume all oxygen, nitrites and nitrates present, making the zone anaerobic. At this point, the microorganisms would release phosphorus into solution. Although the phosphorus concentration actually increases here, it is reduced to well below the influent concentration in the oxic zone.

c. *Anoxic Zone:* Both reactors would contain an anoxic zone, divided into two subzones to improve the efficiency. The zone would be mixed, but not aerated. The mixed liquor would flow from the anaerobic zone into the first anoxic subzone. Return sludge would be pumped in from the secondary clarifiers into the first subzone, and nitrified mixed liquor would be recycled from the end of the oxic zone into the second subzone; both would provide nitrites and nitrates (NO_x). The mixed liquor at this point is anoxic because the only available oxygen present is bound up in the NO_x. Certain microorganisms can break down the NO_x and use the oxygen to consume some of the BOD (typically 15-25% of the influent). The remaining nitrogen is released as gas, mostly in the oxic zone. By consuming the NO_x they denitrify the wastewater. The size of the anoxic zone and the nitrate recycle flow rate control the extent of denitrification; both would be sized to denitrify all year-round. About 20% of the BOD is consumed in the anoxic zone.

d. *Mixed Liquor Recycle Pumps:* Each reactor would get one 1 horsepower variable speed submersible pump, set at the end of the first anoxic subzone in each reactor. Combined, the two mixed liquor recycle pumps would return denitrified mixed liquor at a rate equal to 100% of the average influent flow. Variable speed capacity would be provided so the pumping rate can be increased over the years as the influent flow increases due to growth.

e. *Oxic Zone:* The oxic, or aerobic zone, would receive denitrified mixed liquor from the anoxic zone, which also would have elevated phosphorus levels due to the release in the anaerobic zone. Ammonia would be nitrified (converted to nitrite, then nitrate) and BOD would be consumed in the oxic zone. In addition, both the phosphorus from the raw wastewater, plus the phosphorus released in the anaerobic zone would be taken up, a process known as "luxury uptake". The zone would be divided into two oxic subzones, separated from each other by baffle walls. The baffle walls are needed to prevent short-circuiting and to keep the mixed liquor flowing as a plug from the anoxic zone to the first oxic subzone, then the second. Water will flow through small ports in the bottom and over the top of the baffles. Reactor 1 would include the original sludge holding tank as part of its oxic zone, making it 10,500 gallons larger than Reactor 2. The simplest operation would be to split normal flows equally, and then double the flow that is step fed to Reactor 1.

f. *Nitrate Recycle pumps:* Two variable speed submersible pumps would be set in the effluent drop box following the last oxic zone in each reactor. Combined, the four mixed liquor recycle pumps would return nitrified mixed liquor to the head of the second anoxic subzone at a rate equal to 400% of the average influent flow. Variable speed capacity would be provided so the pumping rate can adjust automatically to maintain a constant percentage of the influent flow.

g. *Diffused air systems:* fine-bubble membrane air diffusers would aerate the oxic subzones in the VIP reactors. The diffusers would be set in a grid pattern on the bottom of the aeration tanks, fully covering the tanks with rows of PVC pipe. The rows would be set far enough apart for an operator to walk between them for service. The diffusers themselves would be made of EPDM rubber and perforated with tiny slits. The pressure from the aeration blowers would force the slits open and tiny bubbles of air would escape, providing mixing and aeration for the mixed liquor. The fine bubble diffusers would have an oxygen transfer efficiency (OTE) several times greater than the existing surface aerators have, so the operating horsepower for the new aeration system would be about the same as the existing while more than doubling the treatment capacity.

   If diffusers need to be replaced, the operator would be able to remove one reactor from service, make repairs, and return the tank to use within two days. Each oxic subzone would have an independent air diffuser grid with its own isolation valve.

h. *Aeration blowers:* Five aeration blowers are proposed: three for the reactors, one to serve both aerobic digesters, and a common spare. All five would have variable capacity. The three reactor blowers would be able to meet the maximum oxygen demand, and sufficient turndown would be provided so one blower operating at minimum capacity can meet the minimum demand. Dissolved oxygen (DO) probes would control the blower operation, turning them on and off and varying their capacities to maintain DO within a narrow range.

Cyclical aeration of the digesters is also recommend to encourage denitrification. The alkalinity and dissolved oxygen credits from this would improve sludge settlability, effluent quality and reduce operating costs. The blower serving the digesters would be turned on and off by a time clock in the computer software. The operator would set this time cycle based on operational experience.

i. *Step Feed (Peak Flow Bypass):* Activated sludge processes fail at peak flows because activated sludge biomass washes out of the reactors and into the clarifiers. If the peaks continue long enough, solids are flushed out of the clarifiers into the disinfection system and then into the receiving stream. One successful method is to bypass part of the peak flows into the last oxic subzones, using them as contact stabilization tanks. Because all raw wastewater would be treated biologically, this method would not violate EPA's new policy prohibiting "slip streaming." The distribution box should incorporate a peak flow bypass with weirs that feed the latter part of the reactors. The dilute wastewater only needs a couple of hours of contact time to consume the BOD, and this keeps most of the solids in the reactors. Biomass does not wash out and the bioreactor meets the permit limits at higher flows. Because solids are retained, the reactors do not need to recover from washout, so long-term treatment efficiency is undiminished. This is similar to the bypass mentioned with the VLR, but better because only 30 percent of the total reactor volume is subject to peak flows, so the washout potential is lower. Reactor 1 would include the original sludge holding tank as a third oxic subzone, making it 10,500 gallons larger than Reactor 2. The simplest operation would be to split normal flows equally, and then double the flow that is step fed to Reactor 1.

j. *VIP Reactors Summary:* Costs were developed for two biological reactors with a combined volume of 111,000 gallons. The hydraulic detention times would be 1.4 hours anaerobic, 4.8 hours anoxic, and 10.4 hours oxic, or 16.6 hours total. Reactor 1 would be 45 feet long while Reactor 2 would be 53 feet long; both would be 15 feet wide, and 10.5 feet deep.

II. Vertical Loop Reactors:

The Vertical Loop Reactor is basically an oxidation ditch turned on its side with a horizontal baffle separating the upper and lower zones. Oxidation ditches are one of the oldest and most common nutrient removal processes, with many patented variations. Originally they were constructed like trapezoidal ditches with concrete poured on earthen walls, and the name stuck, although construction is different today. The mixed liquor flows in a loop with influent fed at one point and effluent drawn off at another. The VLR proposed for Lynn Township is similar to one popular variation on the oxidation ditch where two ditches operate in series, with the first serving as the anoxic zone and the second as the oxic zone.

a. *VLR Volume:* The process analysis, modeling, and cost estimate are based on VLR's with a hydraulic detention time of 18.8 hours at average flow. The existing walls between the aeration tanks and the sludge holding tanks would need to be demolished.

b. *Hydraulic Detention Time:* Oxidation ditches are typically low-load processes where the influent is completely mixed with the mixed liquor and as a result, the reaction rates are slower than plug-flow processes and more detention time is needed to produce the same effluent quality. Ditches normally have hydraulic detention times (HDT's) of 24 hours or more, based on the average daily flow. The manufacturer indicates that the VLR would need 140,000 gallons of volume to treat 160,000 gpd or a detention time of 21 hours. However, the water level could be safely increased only 1 foot to 11.5 feet by raising the walls, making the total available volume of the two reactors 125,000 gallons, or a HDT of 18.8 hours at 160,000 gpd. Modeling has demonstrated that this would be overly aggressive, especially given that the peak flows are more than 3 times the average.

c. *Anoxic VLR:* when two VLR's are operated in series, as is proposed here, the first serves as the anoxic zone. A surface aerator would mix the tank. Minimizing dissolved oxygen in the anoxic zone is critical to denitrification, yet an aerator is proposed to provide mixing in addition to 50% of the process oxygen being fed here. If that much air is fed, it is hard to see how this reactor would ever become anoxic and it certainly will not be anaerobic. Peak flows will compound the difficulty in forming a stable anoxic zone because they normally have high dissolved oxygen levels. The original proposal is based on nitrification and denitrification occurring in the same reactor, which is difficult to consistently achieve.

d. *Filamentous Bacteria Control:* A critical advantage of a well-designed nutrient removal process is the ability to control the growth of filaments and produce a sludge that settles well. The sludge volume index (SVI) measure how well a sludge settles. Filamentous bacteria need either low dissolved oxygen or low loading conditions to out-compete other microorganisms. Filaments cause foaming and bulking sludge that does not settle in clarifiers, making them very prone to washouts during peak flows. Excessive filaments will cause permit violations for TSS and BOD. Oxidation ditches are notorious filament breeders because they are low-load processes that have low dissolved oxygen conditions at some point in their process. Aerating the first VLR while trying to operate in an anoxic mode will encourage the growth of filaments, not control them.

e. *Anoxic and Oxic HDT's:* By using one of the two VLR's as the anoxic zone, the anoxic HDT at average flows would be 9.1 hours, which is excessive. The Wastewater Treatment System Expansion/Upgrade Feasibility Study dated September 2006 mentions the possibility of luxury uptake of phosphorus by microorganisms. With the proposed aerator as a mixer, true anaerobic conditions are unlikely and the BPR will be limited to what occurs inside flock particles. The second VLR would be mixed and aerated to serve as the oxic zone. The aerobic HDT of 9.1 hours would be low for a complete-mixed process.

f. *Oxygen Transfer:* The VLR's aeration system is a combination of conventional coarse bubble air diffusers set under a horizontal shelf and conventional surface brush aerators. Both aeration devices were evaluated based on accepted criteria for their oxygen transfer efficiency. It should be noted that surface aerators reduce the mixed liquor temperature, which lowers the reaction rates, requiring a longer detention time to achieve the same results. The VLR process was modeled at a slightly lower temperature than the VIP.

g. *Horizontal Shelf Structure:* The horizontal shelf is necessary to create the oxidation-ditch effect with mixed liquor flowing across the top of the shelf, down the end wall, along the bottom of the shelf, and back up the far side through the Air Release Plate. The Author observed the conversion of existing aeration tanks into VLR reactors at Selinsgrove and noted how difficult the construction of the horizontal shelf was. In structural terms, the shelf is an elevated floor slab that must be supported, and doweling into the existing concrete walls will not be adequate. The cost estimate includes vertical walls to support the shelf.

h. *Vertical Loop Reactor Summary:* Costs were developed for the two VLR tanks with a combined volume of 125,000 gallons. The hydraulic detention time would be 18.8 hours based on the designed daily average flow of 160,000 gpd. VLR Reactor 1 would be 53 feet long while VLR 2 would be 44 feet long. Both would be 15 feet wide by 11.5 feet deep. The Length-to-Width ratio of the existing aeration tanks is low, the proposed detention time is low and the anticipated oxygen transfer efficiency is also low. The system is complicated with surface aeration mixers plus coarse bubble diffusers set beneath a horizontal shelf.

f. Secondary Clarifiers

The secondary clarifiers serving the VIP Biological reactors would be the same as with the VLR. There is currently one 20-foot in diameter, 14-foot deep clarifier that will continue to be used; this unit is fairly new and performs well, so it would continue in its present use. A second, 30-foot in diameter, 12-foot deep clarifier will be constructed to account for future additional flows that coincide with the wastewater treatment plant expansion. The combined surface area of one 30-foot clarifier and one 20-foot clarifier would be 1020 square feet. The flow capacities with the two clarifiers would be 408,000 gpd at average daily flow and 816,000 gpd at peak flow. Operations would be more complex because different return rates from the clarifiers would be needed. However, two 20-foot clarifiers would not have enough peak flow capacity, so in this case the added peak flow capacity outweighs the difficulties.

The surface overflow rate (SOR) for the new 30-foot clarifier and the 20-foot clarifier combined would be 157 gallons-per-day per square foot (gpd/sf) at an average flow of 160,000 gpd and 588 gpd/sf at a peak flow of 600,000 gpd.

Mixed liquor from the reactors would be fed into the center of the circular clarifiers. A weir would run around the full perimeter of the tank, and the clarified effluent would overflow into an effluent trough, or launder. Together the two clarifiers would have quite a long detention time. The longer the water is in the tank the clearer it will become, as even very small sludge particles settle out. However, the sludge must be rapidly removed from the clarifier in order to keep it from denitrifying in it. The existing clarifier uses a Tow-Bro sludge collector that rapidly removes the sludge by vacuuming it to the center well, from which the return sludge pumps would draw. The new clarifier would include the same collector.

g. Clarifier Influent Distribution Box:

The expansion would include a clarifier influent distribution box using weir gates to control flow. The length of the gate feeding each clarifier would be proportionate to its percentage of the total flow capacity. For sizing purposes, the gate for the 20-foot clarifier should be 4/9ths as wide as the gate for the 30-foot clarifier.

h. Return Sludge Pumping:

The return sludge pumps serving the VIP Biological reactors would be the same as with the VLR process reactors. All pumps should have variable speed drives, with the option to flow-pace return sludge (increase and decrease the return sludge pump rate to the a constant percentage of the influent). One variable speed pump would be dedicated to each clarifier to return the sludge from it to the reactors. The return sludge pumps would have variable flow capacity that would allow flow to range between 50% and 150 % of the design average daily flow.

i. Waste Sludge Pumping:

The return sludge pumps would be used to waste sludge from the secondary treatment process to the aerobic digesters. Two motor operated valves would operate simultaneously, shutting off return sludge flow to the reactor influent distribution box and opening the waste sludge feed to the digesters. The operator would control the quantity of sludge wasted by adjusting the amount of time per day the valves are switched to divert sludge to the digesters. Ideally the operator should spread the sludge wasting out over at least four intervals per day. By using the return sludge pumps, the wasting rate could be as high as 150% of average flow, but this should only be needed when draining the clarifiers for maintenance. Waste sludge solids concentrations from the Tow-Bro sludge collectors should average 0.7 %.

j. Aerobic Digesters:

Scum and excess activated sludge would be wasted from the secondary clarifiers to the aerobic digesters. They would hold the sludge a minimum of 20 days, during which time the sludge is digested, reducing its volume and stabilizing it by reducing pathogens. The sludge would also be concentrated by allowing the digester to settle daily and drawing relatively clear liquid, known as supernatant, off the top. The scum is also concentrated by allowing it to settle daily and drawing off of the top relatively clear liquid, known as supernatant. Two aerobic digesters would be used to provide redundancy in case one is taken out of service. The digesters could be built of either precast concrete or cast-in-place concrete along side each other using common wall construction. Common wall construction refers to laying the tanks out so two tanks share a common wall; this reduces the amount of concrete needed by up to a third.

The aerobic digesters servicing the VIP reactors were assumed would be the same as those used to service the VLR reactors. Costs were developed for two aerobic digesters with a combined volume of 72,000 gallons. The hydraulic detention times would be 20 days based on average sludge production. Each digester would be 28 feet long, 15 feet wide, and 12 feet deep. The two would be built side-by-side.

k. Inlet and Outlet Controls:

Every treatment stage would be provided with inlet and outlet controls to allow units to be isolated for maintenance. Grooves for stop plates would allow both screen channels to be dewatered. With both plates in, the influent pump station could be drained, although this would cause the interceptor to back up and it could only be done for short periods at low flows. Also, bypass piping would be installed so a portable pump could be used if a pump needs to be replaced. The optional grit unit would have isolation valves. Influent weir gates would control flow into the reactors and secondary clarifiers, and fixed weirs would control the effluent from the reactors and clarifiers. All sludge pumps and blowers would have isolation valves on the inlet and outlet. The UV system would be maintained by taking individual lamp racks out of the channel, rather than bypassing the channel, so inlet and outlet controls are not needed there.

l. Automated Controls:

Nutrient removal requires a finer degree of process control than the existing conventional secondary treatment process; therefore automatic controls should be installed as part of the plant expansion and upgrade. Programmable Logic Controllers, a Motor Control Center, an Emergency Generator and a variety of field instruments would all be networked into a desktop computer to provide the operator with the ability to instantaneously respond to changing conditions.

m. Disinfection:

Ultraviolet light radiation is proposed to replace chlorination as the method for disinfecting the effluent from the Lynn Township Wastewater Treatment Plant. UV disinfection is impacted by the effluent quality, which should be very good for the new process. The effluent BOD and Total Suspended Solids, two of the primary criteria for UV disinfection, should average below 10.0 mg/l. The raw wastewater should not contain unusual levels of dissolved solids, metals, or color, three pollutant categories that can affect UV performance by reducing the transmittance of UV light through the wastewater.

An ultraviolet light system is proposed to replace the existing chlorine disinfection process. The current chlorine contact tank room would be used and modified for use with the ultraviolet light system. UV lamps, set in waterproof quartz tubes, would be submerged lengthwise, parallel to the flow. Effluent would pass along and in between the lamps, and the UV light would kill harmful microorganisms. The lamps are set in modules consisting of parallel rows of vertical racks of lamps spanning the width of the channel. Spare lamps and racks would be provided, so the operator could change out any component that needs service. In addition, two separate UV modules could be provided in the UV channel, so the backup would come on automatically if the primary unit fails

n. Reed Beds:

Reed beds are currently utilized at the Lynn Township Wastewater Treatment Facility for dewatering purposes as well as for the reduction in the volume of biosolids, which are utilized by the growth of the reeds. Normal design criteria for reed beds typically have digested biosolids applied every 7-21 days, but are not removed from the system for six to eight years. Reeds are harvested or cut down leaving 6-12 inches of stalk remaining for the plant to grow from the following year. Typically the harvested reeds are disposed of on site by burning.

Volatile solids concentrations should be 70 percent or less for application to reed beds. Higher concentrations may result in negative effects such as odors, slime layers and reed mortality. If the final product is to be land applied following its removal, grit removal or screenings should be removed before application to the reed bed in order to avoid any visible waste materials such as plastics, sanitary products and grit itself.

The existing reed beds will need to be expanded in order to account for increasing flows generated from development within the service area. There are currently 4 reed sludge drying beds at Lynn Township that are each 25 feet by 25 feet in size. The current reed beds provide a usable volume of 65,500 gallons. With a calculated sludge flow rate of 1820 gallons per day the retention time within the existing reed beds would be 36 days. The reed beds need to be able to hold 90 days of sludge. Therefore, at the design flow sludge rate, this requires that the beds be able to contain 164,000 gallons. With each additional 25-foot by 25-foot reed bed holding 16,400 gallons, 6 additional reed beds would be needed to handle the design flow of 160,000 gallons per day. In the Lynn Township Sewer Authority Wastewater Treatment System Upgrade/Feasibility Report dated August 2006 (pg 5-1) from ARRO Consulting, Inc. recommended doubling the size of the reed beds. Our calculations determine that the reed beds will be need to be expanded by 150%.

o. Sludge Pumping and Dewatering (Optional):

The belt filter press is presented as an optional sludge dewatering system, one that is commonly employed for WWTP's with design average daily flows ranging between 100,000 to 500,000 gallons per day. Sludge would be pumped from the aerobic digester to the belt filter press. Polymer would be injected into the sludge pipe running from the digester, either before or after the pumps. The mechanical action reduces the amount of the water in the sludge by many times which causes the sludge to be dry enough that it can be disposed of in a municipal solid waste landfill. Solids concentrations in the feed sludge would be 2% or lower, and the output solids would be 14 to 18%. The effectiveness of the press would depend greatly on the sludge characteristics at any given treatment plant. Compared to the current sludge handling, where about half of the annual sludge load is placed on the reed sludge drying beds and the other half is hauled to a nearby WWTP, a belt filter press has about a 20% greater capital cost, but lower annual O&M costs.

The belt filter press has a fairly large footprint requiring a decent amount of floor space. It is an open system; only the sides are partially enclosed. There are not significant sludge odors, but there is a lot of water spraying about, thus it is not a very clean operation. At Lynn Township a new building would be needed which would need to be well ventilated, and the operator would have more clean-up work than with the other systems. Historically belt filter presses were the most cost effective system to build and run for operations near and above 1.0 MGD ADF. The capital cost was also much lower. The problem was that for years the smallest belt presses were one meter wide, which is about right for a 1.0 MGD-plant. As a result they were rarely used in plants this small. However, about 10 years ago several belt press manufacturers started building smaller versions of their presses and so they have become very cost effective, and more common at smaller plants.

p. Summary:

The Lynn Township wastewater treatment plant is proposed to be expanded to a capacity of 160,000 gallons per day to accommodate growth in the Village of New Tripoli as well its neighboring areas that would easily be served by the collection system.

VIP Process:

The Virginia Initiative Plant process alternative with a Step Feed for high flows is recommended to be implemented. The VIP would consist of, in order: mechanical screen, influent pump station, grit removal (optional), reactor flow distribution box, two VIP biological reactors, clarifier flow distribution box, 1 existing 20-foot plus 1 additional 30-foot diameter secondary clarifier, UV disinfection and a parshall flume. The existing aeration and sludge holding tanks would be converted into the VIP reactors. Separate pumps would be provided to recycle mixed liquor, recycle nitrates, return and waste sludge. Three aeration blowers would serve the reactors, one the digesters, plus a common spare. Sludge handling would consist of two aerobic digesters, and either the reed sludge drying beds or the optional belt filter press. The existing building would contain the aeration blowers, the RAS/WAS pumps and the treatment process controls. A new emergency generator large enough to serve the entire plant would be set outside. Table V-3 presents the costs of the system. Figure V-1 is a treatment process schematic, Figure V-2 is a Preliminary Site Plan and Figure V-3 is a proposed treatment-building layout.

Lynn Township Sewer Authority		
Table V-3		
160,000 gpd VIP Wastewater Treatment Plant Expansion		
Opinion of Probable Cost		
Treatment Unit		Cost
Headworks including Inflluent Pump Station		$ 246,000
Biological Reactors, Aerobic Digesters & Reed Beds		$ 559,500
Treatment Building incl. Blowers & Generator		$ 208,100
Ultra Violet Light Disinfection		$ 75,000
Clarifier		$ 247,800
Flow Distribution Boxes		$ 64,000
Site Work		$ 52,000
Yard Piping		$ 20,000
	Subtotal:	$ 1,472,000
Electrical incl. power dist., instruments & controls		$ 162,000
Heat, Ventilation & Plumbing		$ 20,000
Materials & Installation Subtotal:		$ 1,654,000
Overhead, Profit, Mobilization & Insurance		$ 331,000
Total Construction Cost:		**$ 1,985,000**
Engineering, Legal, Administration, Finance		**$ 496,800**
Contingency (15%):		**$ 372,000**
Total Project Costs:		**$ 2,853,800**
Number of EDU's	634	
Total Project Cost per EDU:		$4,500
Optional Treatment Unit Processes		Cost
Grit Removal System		$ 116,000
Belt Filter Press		$ 199,000
Scum Pump Station		$ 36,000

VLR Process

The Vertical Loop Reactor process alternative for high flows is not recommended to be implemented because it is incapable of achieving the stated effluent criteria. The VLR would consist of, in order: mechanical screen, influent pump station, grit removal (optional), reactor flow distribution box, two VLR biological reactors, clarifier flow distribution box, 1 existing 20-foot plus 1 additional 30-foot diameter secondary clarifier, UV disinfection and a parshall flume. The existing aeration and sludge holding tanks would be converted into the VLR reactors. The VLR process would include its own brush aerators, internal deflector baffles, coarse bubble diffusers, and process controls. Three aeration blowers would serve the reactors, one the digesters, plus a common spare. Sludge handling would consist of two aerobic digesters, and either the reed sludge drying beds or the optional belt filter press. The existing building would contain the aeration blowers, the RAS/WAS pumps and the treatment process controls. A new emergency generator large enough to serve the entire plant would be set outside. Table V-4 presents the costs of the system. Figure V-4 is a Preliminary Site Plan and Figure V-5 is a proposed treatment-building layout.

Lynn Township Sewer Authority		
Table V-4		
160,000 gpd VLR Wastewater Treatment Plant Expansion		
Opinion of Probable Cost		
Treatment Unit		Cost
Headworks including Inflluent Pump Station		$ 246,000
Biological Reactors, Aerobic Digesters & Reed Beds		$ 950,700
Treatment Building incl. Blowers & Generator		$ 208,100
Ultra Violet Light Disinfection		$ 75,000
Clarifier		$ 247,800
Flow Distribution Boxes		$ 64,000
Site Work		$ 52,000
Yard Piping		$ 20,000
	Subtotal:	$ 1,864,000
Electrical incl. power dist., instruments & controls		$ 205,000
Heat, Ventilation & Plumbing		$ 20,000
Materials & Installation Subtotal:		$ 2,089,000
Overhead, Profit, Mobilization & Insurance		$ 418,000
Total Construction Cost:		**$ 2,507,000**
Engineering, Legal, Administration, Finance		**$ 496,800**
Contingency (15%):		**$ 372,000**
Total Project Costs:		**$ 3,375,800**
Number of EDU's	634	
Total Project Cost per EDU:		$5,300
Optional Treatment Unit Processes		Cost
Grit Removal System		$ 116,000
Belt Filter Press		$ 199,000
Scum Pump Station		$ 36,000

2) Extension of Existing Collection System (ARRO 537)

According to the Act 537 Sewage Facilities Plan Update for Lynn Township dated October 2005, there is potential to expand the existing sewer system within the New Tripoli Service/Planning area to serve proposed residential and commercial developments. These developments could produce 150 to 250 EDU's within the next five years increasing flow into the treatment facility by 37,500 to 62,500 gallons per day.

3) Regional Wastewater Collection Alternatives (ARRO 537)

The existing treatment plant is not a regional wastewater collection plant. The drainage area into the plant is roughly 3,000 acres. Due to the rural nature of the township as a whole, no regional wastewater collection system will be an option.

4) Continued Use of Existing Facilities

Several components of the existing WWTP will be reused in their present form, or converted to new uses. The project's goal will be to maximize the effective re-use of existing structures. For example, the existing aeration tanks will be modified for an activated sludge process.

a. Upgrading

A large percentage of the current facility is capable of being upgraded for use in a treatment alternative other than the existing extended aeration process. The existing aeration tanks can easily be modified into a nutrient removal process. The existing clarifier will continue to be used in parallel with a new clarifier. The current reed beds will continue to be utilized as new reed beds are being built alongside of the existing ones.

b. Reduction in Hydraulic or Organic Loading.

The Sewer Authority has made an effort to reduce inflow and infiltration problems throughout the service area. Additionally, the Authority has developed a Corrective Action Plan to try to reduce the hydraulic and organic loading within the facility that will be implemented until the plant is upgraded or expanded.

c. Improved Operation and Maintenance.

The operation of the plant itself has been satisfactory. It is kept clean and well organized, with detailed record keeping. Operating systems appeared well maintained. This should continue with an upgrade to selected activated sludge process.

d. Summary

Lynn Township's Treatment plant while still functional is experiencing frequent hydraulic overloading and less frequently organic loading. With anticipated development in the service area, flows will increase. Additionally, there are sever I & I problems within the service area that cause the plant to experience flows that are 7.5 times larger than their design flow capacity. Therefore, it is imperative that the facility upgrade to a treatment process that capable of handling these increased flows, especially during storm flows.

5) New Community Systems (ARRO 537)

New community systems are not needed for Lynn Township because lot sizes outside of the sewer service area lot sizes are generally larger than 1 acre, and thereby capable of on-lot disposal.

6) Innovative/Alternative Collection (ARRO 537)

Lynn Township has not explored innovative and alternative collection methods because the Township feels that the sewage treatment facility is the best method to serve the residents.

B. Individual Wastewater Systems including IRSIS (ARRO 537)

Individual wastewater treatment facilities are common in rural areas. There are currently no spray irrigation systems. The area surrounding the existing wastewater collection system is served by individual systems. Where public sewer is not available in the planning area, on-lot disposal systems (OLDS) will continue to be utilized as the acceptable alternative to sewer disposal.

The Subdivision and Land Development Ordinance require a hydrogeologic study if the size of the development would impact the area as determined by the Board of Supervisors.

Records of all repair, replacement and upgrading of existing OLDS systems has been ongoing for over 20 years. A map of all of the repairs completed in the past 30 years is located in the Appendix of the Act 537 Sewage Facilities Plan Update for Lynn Township dated October 2005 on the On-lot Sewer Systems Repair Map.

The Township currently has plans to establish a new Sewage Management Program for on-lot subsurface sewage disposal facilities. A sample copy of this proposed ordinance is included in the Appendix of the Act 537 Sewage Facilities Plan Update for Lynn Township dated October 2005.

The EPA has mandated water conservation devices for many years. All new homes employ water conservation devices. Older homes are also converting to them as they replace plumbing fixtures. Adding water conservation devices is the first step in addressing malfunctions. The Township employs best management practices when fixing malfunctions by, in sequence, reducing wastewater quantity, repairing the existing system, expanding it, and last, replacing it only when necessary. Residences with failing OLDS will be advised to change their plumbing fixtures as needed.

C. Small Flow Treatment Facilities and Package Wastewater Treatment Plants – N/A

The term "package WWTP" is a bit outdated, with the traditional concept being a modular steel plant delivered completely assembled to the plant site. One or more modules would be set in the ground, piped- and powered-up, and start treating wastewater. The manufacturer would provide the complete system, including treatment equipment and controls, an arrangement known as "vendor engineering." They were cheap and inexpensive; being made of carbon steel, they were not built to last. Most need replaced after 20 to 30 years.

Package plants were commonly employed for small systems receiving up to 100,000 gpd, whereas traditional site-built concrete plants were normally used in larger systems. Now, modular construction, with either precast concrete or steel, is used to build treatment plants as large as 1,000,000 gpd. The concrete tanks are fairly durable when built by a reputable manufacturer, and the steel tanks can be if provided with high quality coatings and cathodic protection. However, our experience with recent local projects has been that package plants cost at least as much as custom-designed WWTP's and we have experienced severe problems dealing with the manufacturer.

Manufacturers package their treatment equipment with either steel or precast concrete tanks, offering a single supplier for the entire system, but this marketing strategy does not fit the classic definition of a package plant. Costs were developed using components designed specifically for the sites by study team engineers who specializes in wastewater treatment. Because the systems would not be "vendor engineered" we would not consider them package plants.

A developer may propose small flow treatment facilities and package plants for isolated development where soils/slopes do not permit spray irrigation; many areas have this limitation on growth. The regional collection system will provide public service for the majority of the study area. SFTF's and package WWTP's will not be allowed anywhere within the study area. All developers will be required to extend the collection system to their development.

No SFTF's or package WWTP's are recommended as part of this Plan Update.

D. Community Land Disposal (ARRO 537) – N/A

No Community Land Disposal Systems are recommended as part of this Plan Update.

E. Retaining Tanks (ARRO 537)– N/A

No Retaining Tanks are recommended as part of this plan Update

F. Wastewater Management Programs (ARRO 537)

Within Lynn Township, ownership of individual OLDS systems or small flow wastewater treatment facilities will be on an individual basis, the Township will not be involved in the ownership. As part of the permitting process, an individual sewage management plan will be developed.

Finally, a joint municipal sewage management program is not required because there are no other municipalities involved. Due to the rural nature of Lynn Township individual property owners must be responsible for the maintenance and upkeep of their systems.