Redevelopment Plans in Pennington
- **A unique opportunity to coordinate the solutions to multiple issues.**

by Andy Jackson, 4 Walking Purchase Drive, Pennington.

[Note that I am submitting this to the Redevelopment Committee as a concerned resident with an engineering background, not in my capacity as a member of the Planning Board, the Master Plan Committee, or the Environmental Commission.]

1. Introduction

I believe that three of the current redevelopment projects, the Wells Fargo Bank site, the Landfill site and the Blackwell site, should be planned in a coordinated manner. The common element to all is that they lie in the Lewis Brook stormwater catchment area and are critical for stormwater management. This document presents an argument for coordination and addresses how value can be created from the three projects while managing stormwater.

Along this route, several other issues should be addressed in the Land Use Plan being prepared for Master Plan 2025. This targets 2035, with a long-term view for large scale projects to 2050. What Pennington should avoid is a piecemeal approach to individual issues that could jeopardize an optimized solution for all.

Listed below are 19 issues, from the border with Hopewell Township on Pennington-Titusville Road (West Delaware Avenue) to the junction of Eglantine Avenue and East Franklin, and on to Stony Brook at Rocky Hill Road. Some are already goals in other elements of Master Plan 2025. Each will be addressed individually or collectively in more detail later.

1. Eliminate future flooding along Lewis Brook from extraordinary storms such as Ida (2021, 9.1 inches) and Debby (2023, 9.4 inches) by excavating detention basins.
2. Eliminate flooding at the intersection of Route 31 and West Delaware Avenue by constructing a correctly sized drainage system to the landfill site.
3. The type and location of buildings on the Wells Fargo lot should accommodate solutions to traffic and safety issues at the intersection of Route 31 and West Delaware.
4. The West Delaware Avenue railroad bridge is old (wooden structure - how old?) and frequently needs repair. Sightlines for cars are poor, and the sidewalks are inadequate, especially for schoolchildren from Pennington School and the HVRSD schools.
5. A suggested overpass of Delaware Avenue over Route 31 will need space for off ramps. It could be combined with replacing the railroad bridge. The extended length would free up space adjacent to the landfill, enhancing the value of its redevelopment. An overpass of Route 31 over West Delaware Avenue should be considered as an alternative.
6. What to do with the landfill? – Use as is or remove the waste to a commercial landfill and build a detention/retention basin on the west side with development on the remainder.
7. The return of West Trenton to Bound Brook passenger trains is a DVRPC long-term goal, and an option exists to build a railroad station on the east edge of the landfill, if cleared.
8. Where and what is Lewis Brook on the west side of the railroad tracks? How valid is the riparian zone? How should the flood plain be defined? What is ditch and what is stream?

9. Eliminate flooding under the Broemel Street railroad bridge. The main cause is the undersized tunnels for Lewis Brook under Broemel Place and then Green Street. The County is considering replacing the existing Green St. tunnel, but a better option may be to leave the current tunnels in place and build a new, larger tunnel under Green St. south of Broemel Place to feed into a new channel to Lewis Brook.
10. CSX needs to replace the obsolete Broemel Place railroad bridge. It was built in 1937 and is in visibly poor condition.
11. How to make best use of the Blackwell property when floodplain and riparian zone lines limit the opportunity? Dig a retention basin and move the fill to increase the buildable area. Combine with part of the Pennington School woods to provide a larger basin.
12. The Landfill and Blackwell basins will eliminate flooding on Green St., North Main St. at Lewis Brook, and at the junction of Eglantine Ave. and East Franklin Ave.
13. Replace the small water tunnel under the rear of 20 and 22 East Franklin with a larger one, or daylight the stream across these properties.
14. Determine the life expectancy of the aging Eglantine Avenue bridge over Lewis Brook and, if necessary, replace it with one integrated with the output from 22 East Franklin.
15. Design and build the Landfill and Blackwell basins to limit the maximum flow rate of water in Lewis Brook east of Eglantine Avenue to eliminate flooding of Township properties on Lewis Brook Drive and control the flow into Stony Brook.
16. Secure the SBRSA sewage plant against Stony Brook flooding damage. It came close to being damaged during Ida. Its loss would be a huge problem for Pennington.
17. Confirm that the design of the County's proposed new bridge on Rocky Hill Road over Stony Brook adequately covers anticipated water flow from extraordinary storms.
18. Design the Stony Brook bridge to carry an NJ American Water pipe from Princeton West Campus along Rocky Hill Rd. one mile to King George Rd. for Borough backup water.
19. Consider allowing the rebuilding of the dam that Pennington owns east of the Borough to create a dry detention basin for Stony Brook, up to the Rocky Hill Road bridge.

Two significant components driving the Land Use Plan are stormwater management and meeting the State's 2035 affordable housing targets. Other sections of the Land Use Plan will encompass recommendations from other Plan elements such as conservation, open space, environmental sustainability, and mobility. Mitigation of the negative effects of stormwater will be regulated by the flood hazard area control act rules of N.J.A.C. 7:13 (October 2021). The ability to execute many of the plan components will depend on funding assistance through the County or the State. A means to justify funding is by reference to proposals in a comprehensive Master Plan.

Addressing the above list of 19 opportunities and issues together may seem daunting in view of financial and regulatory constraints. However, breaking it into smaller, interconnected slices that would be addressed at different times in the future makes it easier to envisage. A place to start is whether the idea is physically possible (e.g. water doesn't flow uphill). This can be followed by a determination of economic viability (funding availability, income and tax-revenue generation). Next could come regulatory constraints and allowances for mitigating a more serious issue.

Let's start with stormwater management.

2. Stormwater Management

Serious flooding has occurred in the Lewis Brook watershed in Pennington at the Route31 and Delaware Avenue intersection, in the landfill ditch, under the Broemel Street railroad bridge, on Green Street, on the Blackwell property, on North Main Street, and on Eglantine Avenue. Properties along the way also suffered water inundations as did houses along Lewis Brook Drive in Hopewell Township. The excessive flow rates also added to flooding of Stony Brook downstream from the point where Lewis Brook flows into Stony Brook.

Two recent extreme examples were the remnants of Tropical Storm Ida, which dropped 9.1 inches of rain on Hopewell Township on September 1, 2021 and Tropical Storm Debby with 9.4 inches of rain on August 8, 2024. Both were “200-year storms”, less than three years apart. Shortly after Debby, Tropical Storm Helene dropped over 31 inches of rain on Busick, North Carolina on September 27, 2024, and the flooding along the Swannanoa River devastated Asheville. A major result of climate change is an increase in frequency and severity of rain events. It is necessary to understand the impact on Pennington and what steps can be taken to adapt to these changes.

Appendix A, Section A1 presents an analysis of the amount of water that fell on Lewis Brook catchment areas west of Eglantine Avenue during Tropical Storm Ida. It then converts these to flow rates along the Brook and determines whether the bridges, tunnels, culverts and pipes along the path are adequately sized to cope with the flow. Most were found to be undersized, many very much so. Section A2 proposes detention basins on the Landfill and on the Blackwell and Pennington School property and determines smaller and larger sizes and volumes possible for each from geographic and topographic constraints. Section A3 calculates water flow rate reductions at critical points along the stream with various combinations of the larger and smaller basins temporarily detaining the water.

The main conclusions on stormwater are as follows:

1. During the 1-hour peak of Ida, when 3.29 inches of rain fell, the flow rate at the Eglantine Avenue bridge reached 762 cubic feet per second. The cross-sectional area of Lewis Brook needed below the bridge to contain the flow is 52 sq. ft. if the flow is 10 mph or 104 sq. ft. if it is at 5 mph. The existing area is estimated to be around 50 sq.ft (10 ft. wide by 5 ft. deep). This area flooded during Ida.
2. The semicircular tunnel under the CSX tracks from the landfill is just about adequate at 33 sq.ft. where 26 is required for a 10 mph flow rate. The berm on the north side of the stream adjacent to the fire house parking lot should be extended to the north side of the tunnel entrance to prevent overflow into Broemel Place when the tunnel nears maximum flow capacity. The tunnel entrance should be cleared of stones.
3. The rectangular tunnel under Broemel Place is 20 sq. ft. where 26 is required at its entrance. The problem is compounded by added flow from a pipe from the Broemel-Straube catchment area to the center of the tunnel. This raises the cross-sectional area needed at the tunnel’s exit to 31 sq. ft. so it is inadequate. The Broemel pipe is also too small. The arched tunnel under Green Street is 18 sq,ft. where 31 is required. The consequence of the undersized tunnels and pipe is that the water flows over Green Street, and Broemel Place floods under the bridge from the backflow in the pipe.

4. It is reported that the County is looking to eliminate flooding in this area by building a new bridge under Green Street. I believe that the correct solution to eliminate flooding under the Broemel Place railroad bridge is to build a new Green Street bridge to the south of the Broemel Place intersection and divert Lewis Brook to this bridge and away from Broemel Place. The existing undersized bridges under Broemel Place and Green Street can then be segregated from the main Lewis Brook flow and left in place to drain the Broemel-Straube catchment area. Locating the Green Street bridge to the south would require a new channel to Lewis brook from the east end of the bridge. This would become part of the proposed Blackwell-Pennington School detention basin.
5. The pipe at the east end of the Blackwell property is 3 feet in diameter, 7 sq. ft., where more than 31 is required. It passes under the garage, which is likely to be demolished in any redevelopment. This pipe location would become part of the proposed detention basin. The Main Street bridge appears to be adequately sized but is old (1891).
6. The 5 x 3 ft. tunnel under the backyards of 20 and 22 East Franklin Avenue has an area of 15 sq. ft. where 51.9 is required so is totally inadequate. The water floods the backyards of the properties and flows over Eglantine Avenue to the continuation of Lewis Brook. Options would to daylight the stream or replace the tunnel with a much larger one. The final size would depend on whether the flow can be reduced with upstream detention basins. It would need to be over 50 sq.ft.
7. The Eglantine Bridge is barely adequate and is in a poor state of repair. It should be rebuilt with an appropriate connection to whatever is constructed to carry Lewis Brook across the backyard of 22 East Franklin Avenue.
8. Two possible detention basins are proposed for the southwest side of the landfill. The shorter version, which leaves Well #6 intact, could hold 470,000 cubic feet of water. A longer version that includes the location of Well #6 by extending towards the rising ground near Broemel Place could hold 710,000 cubic feet. Each would be 5 ft. deep, and the high-water elevation would be limited to 183 feet to allow gravity drainage of the intersection of Route 31 and West Delaware Avenue, and the Exxon and Boro Market lots, at 185 feet. If the landfill waste is removed, an economic benefit would come from using the dirt from the detention basins to grow the area outside the floodplain. The developable area in the southern portion of the landfill would go from close to zero to 3.7 acres. The area adjacent to Broemel Place adds additional acreage for development.
9. A new culvert under West Delaware Avenue or the sidewalk is needed, and it should be large enough to drain all the water that flows into the intersection with significant clearance to avoid back pressure to build up and limit the flow. A 10 x 5 ft cross section should work. The current pipe from the intersection looks like it is about 18 inches in diameter, which is totally inadequate for a severe storm. When the culvert is being installed, we should take the opportunity to widen West Delaware Avenue to allow three westbound lanes; left turn, straight and right turn as discussed in Section 4 below. This would allow more through traffic on a green light by avoiding the delays from right-turn traffic giving way to pedestrians crossing Route 31. It would use the available right-of-way on the south side of West Delaware Avenue.
10. The first 300 feet of the current Lewis Brook east of Green Street flows through Pennington School property, so the school would need to be a participant in this flood control project. Two possible detention basins are proposed. The smaller version, which includes a small part of the wooded area belonging to Pennington School, could hold

625,000 cubic feet of water, and include the new channel proposed in 4 above. A larger version that includes more of the school's wooded area could hold 1,180,000 cubic feet. Each would be 7 ft. deep. The fill from the basin can be relocated to increase the developable area outside the floodplain to about 2.2 acres.

11. Both the Landfill and Blackwell basins could be dug 3 or more feet deeper to become retention basins, which can be landscaped ponds. The extra fill can be used to further increase the development areas outside the floodplains.
12. The analysis of flow rate reductions possible with the detention basins showed that for the 1-hour peak flow volume, the flow at Main St, is reduced by the two large basins to 30% of that without basins and was reduced at Eglantine to 58%. The corresponding numbers for the combination of the small landfill basin and the large Blackwell basin are 33% and 60%. The slightly lower reductions may be acceptable since Well #6 could remain in use.
13. The proposed new bridge taking Pennington-Rocky Hill Road over Stony Brook should be large enough to ensure that the water from the worst predictable storm can pass under the bridge without flowing over the road deck. Overflow has been experienced in the past. Further downriver, we should ensure the beavers aren't allowed to build a dam like the one which built up Stony Brook water levels to an extent that threatened the sewage plant control room. We should consider rebuilding the dam that Pennington owns east of the Borough to 138 feet high with a choke and overflow to create a retention basin for Stony Brook that would extend upstream beyond the Rocky Hill Road bridge. This could slow down about 500,000 cu. ft. flowing towards Princeton during the peak of a storm.
14. To understand the NJ DEP restrictions on development due to riparian zones, floodplains and wetlands, the question of where Lewis Brook runs on the landfill site should be addressed. A 1950 Fire Map shows that the original route of Lewis Brook was diagonally across the landfill site and a 1966 aerial view of Pennington confirms this. Shortly after this, a ditch was dug along the west edge of the property, leading to a small bridge under the access road, which still exists. A continuation of the ditch was dug to the tunnel under the railroad. Since neither of these follow the original path of Lewis Brook, they are man-made and should be classified differently from a stream following its natural course. We need to weigh the good from removing the waste, economic development, and a much-needed storm water detention basin against the environmental protections afforded a natural river or stream. Eliminating flooding by elevating the land surrounding the ditch allows development which may make this worthwhile project economically viable.

3. Landfill Redevelopment

The landfill redevelopment starts with a simple question. Do we remove the 15,000 tons of municipal waste and transport it to a modern landfill and restore the land to near-greenfield state or do we leave the waste in place and use the area for purposes permitted on a brownfield site. Several ideas have been floated for brownfield site use, such as an entertainment arena, a mountain-bike course, a solar field or simply leave it as is for passive recreation. The problem with these is that only solar could generate revenue for the Borough and it would be small. A Solar Landscape proposal in August 2022 suggested a $40,000/year lease payment to the Borough on a 1 MW system they would install, own, operate, and maintain.

I believe it would be much better to remove the garbage and turn the site back into a greenfield site. The first reaction of many people is that this would be prohibitively expensive, or that the DEP would never allow it. To get an estimate of what it would cost and whether it would be allowed, we should request assistance from the Project Management & Redevelopment division of the Mercer County Improvement Authority (MCIA). Their website says "Our team of project management professionals can provide design, contract administration and construction management services. Additionally, the County Improvement Authorities Law allows the MCIA to act as the redevelopment entity for various redevelopment areas throughout the county. As such, the MCIA facilitates commercial and residential redevelopment with innovative approaches that solve complex development issues." Sounds like a good place to start!

A website search found a landfill relocation project in Old Town Maine, described in a 2021 article; https://www.wastetodaymagazine.com/news/old-town-maine-landfill-waste/
I called John Rouleau, the Old Town Public Works Director, and he told me that the project was completed very successfully. They used local contractors to excavate and move the waste to a commercial landfill five miles away and the site is now grassland. They got permits from Maine DEP and a grant to cover some of the cost. I described our project and he thought it was a "no-brainer", especially if the land had value. He is willing to pass on his experience on this. Other landfill relocation projects were in Camden NJ, Wayne County PA and Folsom CA. I have not contacted anyone at these sites.

Here is a rough estimate of what it would cost to relocate our waste. Typical tipping fees can be found in https://erefdn.org/analyzing-municipal-solid-waste-landfill-tipping-fees/ , which gives $92 +/- 26 per ton in PA and $88 +/- 8 per ton in NJ. Let's call it $100/ton. We have 15,000 tons of garbage, so that is about $1.5 million to dispose of it at a landfill. Excavation cost estimates are all over the map but Homeguide (https://homeguide.com/costs/excavation-cost) gives a 2025 range of $2.50 to $15 per cubic yard for Zip Code 08534. Taking the high end of $15, the 65,000 cubic yards may cost about $1.0 million to excavate. Hauling to the commercial landfill may cost $0.5 million, giving a total cost of $3.0 million for removal and disposal. Is this reasonable? If we simply load the 15,000 tons into garbage trucks it would cost $2.2 million to drop it at the Ewing transfer station, leaving $0.8 million for loading it into the trucks. We are in the ballpark.

A benefit of removing the garbage is that we will avoid the cost of capping the landfill. A 2018 Federal Remediation Technologies Roundtable document estimates $300k to $600k per acre to cap a landfill. Taking an average of $450, plus 25% to go from 2018 to 2025 dollars, our ~4 acre landfill would cost~$2 million to cap. This can be subtracted from the removal cost.
https://frtr.gov/matrix/Landfill-and-Soil-Capping/#Cost

A second benefit is the value of the land that will be released for use as a greenfield site. The next section will talk about potential uses and estimates that ~4 acres will be available to develop. Using the assessment for my house and increasing the assessed value in proportion to the actual value gives a land value of $750k per acre. The 4 acres will have a value of $3 million. The net from removal and redevelopment will be a positive $2 million. Added to this value will be the elimination of ongoing environmental testing fees, and the real estate taxes that will come from redevelopment. My favorite option would be to locate a hotel, such as a TownPlace Suites by Marriott. My wife and I stay at one in Loveland, Colorado. It has 102 rooms and suites and the 4 story building covers about an acre (measured using Google Earth). Grounds and parking would take up some of the additional space.

With or without removal of the waste, there is room to excavate a detention basin capable of short-term storage of stormwater to control flooding. As described in the Section 2 and in more detail in Appendix A, Section A2, the basin area could range from 100,000 to 150,000 square feet with a capacity from 470,000 to 710,000 cubic feet.

4. West Delaware Avenue – Intersection with Route 31 and the bridge over the railroad.

Three goals in the 2025 Mobility Plan address the issues on West Delaware Avenue:
4a: "Develop and implement creative ways to reduce traffic jams at the traffic signal at Route 31 and West Delaware Avenue, including the possibility of an overpass."
4b: "Improve the safety of pedestrians, bicyclists and other low-speed personal vehicles users crossing Route 31 at West Delaware Avenue."
4d: "Request that the County and CSX railroad build a safer bridge on West Delaware Avenue with less steep slopes and clearer sightlines to traffic stopped at the Route 31 traffic light. The bridge should be designed to be safer for pedestrians, bicyclists, and personal mobility users."

Delays at the Route 31 and West Delaware Avenue intersection generally occur in the mornings and afternoons when the High School and Middle School are open. This is also the time when pedestrians and bicyclists trying to cross Route 31 to get to and from school are at highest risk. A problem in the morning is the single westbound lane on West Delaware Avenue both for vehicles going across the intersection and for those turning right. The right turn vehicles can be delayed to allow pedestrians to cross when the light is green, severely reducing the number of vehicles that can cross the intersection in the green light sequence. The same thing happens eastbound in the afternoon but seems to be less of a problem as most pedestrians seem to cross Route 31 on the north side of the intersection, although this can cause a delay for left-turning eastbound traffic.

An inexpensive option to try is to have a button-controlled four-way pedestrian crossing period with all lights at red for perhaps 20 seconds, as is done at the Main Street – Delaware Avenue intersection, followed by a longer-time green light on Delaware Avenue. This would allow right turning vehicles to keep moving, which may slow, but would not stop the westbound vehicles.

A more expensive solution is to use the full 50 foot right of way on West Delaware Avenue to add a right-turn-only lane in both directions. Timing of the traffic light could be as it is now, but there would be no delays for traffic crossing the intersection due to right turners. Right turn traffic may be delayed but if the right-turn-only lanes are long enough, they won't interfere with the through traffic. The unused right-of-way is on the South side of Delaware Avenue and some lane realignment will be necessary. This could be done in conjunction with the design for a future replacement of the railroad bridge. Design needs for a safe intersection may impact the site planning for the Wells Fargo site, particularly for sidewalk width and location.

A very expensive, but perhaps the best long-term solution with traffic expected to increase due to local housing developments and increasing Route 31 traffic due to economic growth, is an overpass. This was proposed in the 2002 Route 31 Design study to alleviate the morning and evening gridlock of the intersection. It could be either Delaware Avenue passing over Route 31 or Route 31 over Delaware Avenue. Either option would eliminate traffic backups on both roads. The challenge is the accommodation of four left turns at the intersection.

Mobility goal 4d, the new CSX bridge, can be incorporated in an elevated roadway with bike lanes and sidewalks starting just west of the new main entrance to the Pennington School parking, crossing over the CSX tracks and Route 31 at a constant elevation, and terminating on Pennington-Titusville Road halfway between the County Library parking lot entrance and the Wells Fargo entrance, where the elevation levels off at 196 feet. The road deck elevation of the current CSX bridge is 213 feet. The Route 31 intersection elevation is 185 feet, leaving 28 feet, more than enough for a 17 ft minimum clearance for trucks on Route 31 plus a typical bridge deck thickness of 5 ft. Maintaining a constant road deck elevation over both the railroad tracks and Route 31would allow Route 31 under the bridge to be raised by 5 feet, to improve drainage and eliminate flooding. The elevated section could also enhance the value of the landfill site, if the waste is removed, by adding 350 x 50 feet (0.3 acres) to the south that can be used for access roads, parking, or covered open space. Note that CSX is not a loss-making railroad. Its profits for the fiscal year 2023-2024 were close to $4 billion and they should be asked to pay to replace the aging West Delaware Avenue and Broemel Place bridges for safety reasons.

Addressing the four left turns with an elevated road is a design challenge. The left turns from southbound Route 31 to eastbound West Delaware and from westbound West Delaware to southbound Route 31 could be accommodated on part of the Wells Fargo site using a quarter clover leaf similar to I-295 eastbound onto Route 31 north and south in Ewing, but at a much smaller scale as the speed limit on Route 31 in Pennington is 35 mph. The two left turns on and off Route 31 northbound will need slip roads up to and down from the elevated section of Delaware Avenue within the existing Route 31 80-foot right-of-way. This would be like the Street Road intersection with I-95 in Pennsylvania. A problem would be that the slip roads would interfere with access to the Exxon gas station and Starbucks. Similar slip roads could be used on the southbound side of Route 31 to avoid taking space from the Wells Fargo site.

A second option is a bridge for Route 31 over West Delaware Avenue. Route 31 has an 80-foot right-of-way, and there should be room to accommodate two traffic lanes with shoulders over the bridge. Slip roads on each side of the bridge leading to and from the location of the current intersection would allow the four left turns. The junction may still require traffic lights, but extra time could be given to traffic on West Delaware Avenue to minimize traffic jams. Care would be needed to accommodate pedestrians and personal vehicle users at the intersection.

There are two other unlikely options that should still be considered. One would be to elevate the railroad on a soundproofed trestle from north of Broemel to south of West Delaware Ave, which could then go under the railroad. The rail bed elevation would need to rise from 188 to 205 feet over Delaware Avenue, which would be at 185 feet. This would connect the Green Street fields to the cleared landfill and create many Land Use opportunities. It would also add elevation to the railbed at Broemel Place, allowing for a full height bridge. The second would be to reconfigure West Delaware Avenue as a grade crossing at the current railbed elevation of 188 feet. CSX does have grade crossings on this route, including one in Skillman. However, it could cause backups on West Delaware Avenue with 150+ car trains and be a danger to pedestrians and bicyclists.

Appendix A. Lewis Brook Flooding Analysis

A1. Catchment areas, water flow and volumes.

Extensive use has been made of Google Earth Pro in developing the data in this appendix. Google Earth is a compilation of satellite images covering the earth's surface. Google Earth Pro has four valuable data features for this type of analysis:

1. The elevation at the point of the cursor in any map view (including ocean depths).
2. A polygon feature that allows a determination of the area within the polygon.
3. A path feature that gives the length of any path, straight or crooked.
4. The Drop Pin feature that allows the location and naming of any point on the map.

Zooming on land is possible from 7000 miles out in space down to about 200 feet above the elevation above sea level, with good resolution down to 400 feet. Trees can obliterate the view, but another useful feature is to roll back to earlier images and if a winter date can be found, lack of foliage will allow more land-level detail to be seen.

The first use of Google Earth Pro was to determine the rainwater catchment area leading to the bridge under Eglantine Avenue at East Franklin. This was done in three parts. The first is the catchment that leads to the landfill and the tunnel under the CSX tracks behind the EMS building, the second is a smaller area that feeds into a small pipe under Broemel Street bridge, and the third is the area east of the railroad tracks that leads to the bridge under Eglantine Avenue. The process followed was to identity the boundaries of each catchment area using the Drop Pin feature, followed by connecting the pins together with a polygon to determine the areas of each. Figure A1 shows the location and size of the three catchment areas. It also shows the path of Lewis Brook using the path feature. Appendix B describes the Drop Pin locations used to define the areas.

The next step was to determine the volume of water falling on the catchment areas as the remnants of Tropical Storm Ida passed over New Jersey. Hopewell Township had some of the highest rain amounts in the state. An excellent report "Ida Remnants Strike New Jersey" by David A,. Robinson of the Office of NJ State Climatologist at Rutgers, dated Oct. 26, 2021, gave rainfall data in Hopewell Township for different periods during Ida, as shown in Table A1.

Table A1 Tropical Storm Ida Remnants Rainfall, Sept 1-2, 2021
https://climate.rutgers.edu/stateclim/?target=Ida

Hopewell Township total 9.13 inches

Peak volumes recorded on September 1, with average recurrence intervals (ARI)

Peak 6-hour period: 7.44 inches ending 10:35 pm.	ARI 500 years
Peak 3-hour period: 5.90 inches ending 8:55 pm.	ARI 1000 years
Peak 2-hour period: 5.16 inches ending 8:40 pm.	ARI 1000 years
Peak 1-hour period: 3.29 inches ending 7:55 pm.	ARI 200 years

Note that the time periods overlap. The peak 1-hour is included in the 2-hour and the 3-hour.

The ARI values are interesting. Less than 3 years later Debby dropped 9.38 inches on Pennington, the highest in New Jersey according to an NJ 101.5 summary of the storm https://nj1015.com/debby-storm-recap-for-nj-over-9-of-rain-50-mph-wind-gusts/ .
Debby was another 200 year + ARI storm! We need to prepare for more of the same, or worse.

With the catchment areas and rainfall rates we can calculate the volume of rain falling on the catchments in the corresponding periods and then determine the volume flow rates into Lewis Brook. Table A2 shows the results of this analysis. It is assumed the all the rain falling onto the catchment areas immediately heads to Lewis Brook. This would be the case if the ground was already saturated from rain earlier in the storm than the peak flow periods. It also assumes that the very few, and small, detention basins along the path are either full or not effective.

Table A2: Calculation of the water flow rates into and out of the catchment areas.

	Landfill	Broemel	Eglantine	Total	rain/hr		
Flow from:	Schools area	Straube area	East of CSX		inches		
Area sqft	5,000,000	1,000,000	4,000,000	10,000,000			
Volume ft3	3,804,167	760,833	3,043,333	7,608,333	9.13	Total storm	
Volume ft3	3,100,000	620,000	2,480,000	6,200,000	7.44	6	hours
Volume ft3	2,458,333	491,667	1,966,667	4,916,667	5.90	3	hours
Volume ft3	2,150,000	430,000	1,720,000	4,300,000	5.16	2	hours
Volume ft3	1,370,833	274,167	1,096,667	2,741,667	3.29	1	hour
Flow ft3/sec	143.5	28.7	114.8	287.0	7.44	6	hour
Flow ft3/sec	227.6	45.5	182.1	455.2	5.90	3	hours
Flow ft3/sec	298.6	59.7	238.9	597.2	5.16	2	hours
Flow ft3/sec	380.8	76.2	304.6	761.6	3.29	1	hours

The next step is to determine if the various tunnels, pipes, culverts and bridges along the route of Lewis brook are adequately sized to remove these volumes of water. The first assumption is the maximum speed of the water flow in the various channels. A full solution to this can only be done by hydrological analysis, but a reasonable estimate can be made by assuming a maximum average velocity for the water in a channel. An easy-to-read article, "How fast are Rivers?" from Goran Safarek's World Rivers project describes the factors that go into the speed of rivers and streams (https://worldrivers.net/2020/03/28/how-fast-are-rivers/). In the introduction to the article, he states that "A moderately fast river drifts along at around 5 kilometers per hour (or 3 miles per hour), but during floods, streams can roar at speeds of 25 kilometers per hour (or 15 miles per hour)—a wild and unrelenting force. Since we don't think Lewis Brook becomes a wild and unrelenting force, we can assume that we want to limit this to 10 mph or 14.67 feet per second. This means that 14.67 cubic feet of water can pass through a cross-sectional area of one square foot every second. Dividing the volume flow rates at the bottom of Table A2 by 14.67 gives the cross-sectional area needed for channels along the way. These are shown in Table A3.

Table A3. Cross-sectional areas of pipes, culverts, tunnels or open stream to accommodate water flow rates from Table A2. Note that this assumes a maximum flow speed of 10 mph for all.

Flow from:	Landfill	Broemel	Eglantine	Total	rain/hr		
	Schools area	Straube area	East of CSX		inches		
Area ft2 for	9.8	2.0	7.8	19.6	7.44	6	hour
10 mph flow	15.5	3.1	12.4	31.0	5.90	3	hours
(14.67 ft/sec)	20.4	4.1	16.3	40.7	5.16	2	hours
	26.0	5.2	20.8	51.9	3.29	1	hours
Landfill plus Broemel:		31.1					

The following is a determination of the adequacy of existing drainage tunnels to drain the water from the Ida one-hour flow rate of 3,29 inches on the catchment areas:

Tunnel from the Landfill under the CSX tracks

The tunnel under the CSX tracks from the landfill ditch and stream can be seen at the rear of the EMS building. Its shape is a semicircle with a radius of 4 feet on top of a base measuring 1 ft by 8 ft. The area is 33.2 sq. ft., which is more than the 26 sq.ft. in Table A3 and is barely adequate. The berm on the north side of the stream next to the fire house parking lot should be extended up to the north side of the tunnel entrance to prevent overflow into Broemel Place when the tunnel nears maximum flow capacity. The tunnel entrance should be cleared of stones.

Tunnel under Broemel Place close to Green Street

After exiting the railroad tunnel, Lewis Brook goes to a rectangular tunnel under Broemel Place close to Green Street. The tunnel is 5 x 4 ft., a 20 sq. ft. area. This is less than the 26 sq. ft. required and is inadequate. The problem is increased by adding flow from the Broemel-Straube catchment area in a pipe running under the road beneath the bridge that terminates halfway down the rectangular tunnel. The pipe looks like it is 2 ft. in diameter, with a cross-sectional area of 3 sq. ft., less than the 5 sq. ft. required in Table A3 and inadequate. The rectangular tunnel now needs to cope with the combined Landfill and Broemel flow, requiring 31 sq. ft. area. The result is that the stream backs up at the entrance to the tunnel and flows over Green Street. Back flow to the drains under Broemel Place bridge, plus flow from Green Street, which is 3 ft. higher than Broemel Place under the bridge, causes the flooding frequently seen there.

Tunnel under Green Street

The water that passes through the Broemel Place tunnel flows into a small basin and into an arch shaped tunnel under Green St. with 7 ft. width and 3.5 ft. depth. This has an area of ~18 sq. ft., which is inadequate for the combined flow from the rectangular tunnel under Broemel. It will also back up and flow over Green St. The County is planning to replace the tunnel under Green Street. They need to replace the Broemel Street tunnel and enlarge the pipe under the bridge roadbed at the same time. Alternatively, they could build the new Green Street bridge to the south of the intersection and divert Lewis Brook to and from it. The Broemel Place tunnel could be blocked off at its southern end and continue to drain the Broemel-Straube catchment area. The whole area needs redesign. The railroad bridge is in poor shape. The 14 ft. clearance is unmarked and is a danger to trucks. It should be increased to at least 16 ft. The road under the bridge should be raised 3 ft. to the height of the Green St. intersection. A girder bridge may free up some height compared with the current bridge, but the rail bed may need to be raised.

Pipe under Blackwell's garage

After leaving Green St, the next obstacle Lewis Brook encounters is the 3 ft. diameter pipe under the Blackwell building at the Northwest corner of the lot. Its area is 7 sq. ft., which is inadequate compared with the 31+ sq. ft. required (31+ because it does not include flow from that part of the Eglantine catchment area that falls on the lot and the surrounding area).

Main Street bridge

I could not get close enough to measure the dimensions of the rectangular tunnel under Main Street, but I estimated 12 x 6 ft giving a 72 sq. ft. area. This is adequate for the 31+ sq. ft. required, but the bridge is old (1891) and does not look in good shape. Water flows over Main Street as the pipe feeding the bridge from Blackwell is too small.

Tunnel under the backyards of 20 and 22 East Franklin Avenue

From Main St., the water flows to a 5 x 3 ft. tunnel with an area of 15 sq. ft. under the backyards of 20 and 22 East Franklin Avenue. According to Table A3, the requirement here is 52 sq. ft. so it is totally inadequate. The water floods the back yards of the properties, bypasses the bridge and flows over Eglantine Avenue to the continuation of Lewis Brook.

Eglantine Avenue bridge

I estimated the Eglantine bridge at 12 x 6 ft, for an area of 72 sq. ft. which is greater than the 52 sq. ft. required and should be adequate. However, it is old and in poor shape. The water flows over Eglantine Avenue because the tunnel feeding the bridge from 22 East Franklin is too small.

Lewis Brook below Eglantine Avenue

Below Eglantine Avenue, Lewis Brook is an open channel to its confluence with Stony Brook. The channel appears to be about 10 ft. wide and 5 ft. deep for a cross section of 50 sq. ft. This is barely adequate. Flooding in this area indicates it is not adequate, which leads to the question:

Is the assumption of a 10 mph flow speed correct?

We know that there was flooding of Lewis Brook south of Eglantine during Ida, which suggests that the assumption of a stream speed of 10 mph is too high. If we reduce this to 5 mph, the peak flow rate in Lewis Brook south of the Eglantine Avenue bridge would still be 762 cubic ft. per second, as shown in Table A2, but the cross-sectional area of the channel needed to carry the flow would be doubled to over 100 sq. ft.. If 5 mph applies to all the tunnels, pipes, and bridges along the path from the landfill, the cross-sectional area of all would be doubled and all would be inadequate. A hydrologist would need to estimate the appropriate speed. A future storm with rainfall rates higher than Ida would also require higher cross-sectional areas. Let what Tropical Storm Helene did to North Carolina in September 2024 be a warning.

Note from Table A2 that the average 6-hour and 3-hour flow rates for Ida at Eglantine were 277 and 455 cubic ft. per second compared with the 762 peak. One way to control flooding during high peak rates is to temporarily capture the peak rain in upstream detention basins and release it over a longer period. Two locations for detention basins are the Landfill and the Blackwell sites. Section A2 studies the geography and topography of these sites to determine where they could be located, what water volume they could hold, and how downstream flow rates could be reduced.

A2. Detention Basins on the Landfill and Blackwell sites.

Figure A2 is a topographic schematic of the water flow from the frequently-flooded Route 31 and West Delaware Avenue intersection, through the landfill, under the CSX tracks and Green Street, and across the Blackwell property to Main Street. Elevations and distances are to scale but note that the distance axis is 200 times larger than the elevation access. Elevations were obtained using Google Earth Pro. The distances were obtained from Google Earth Pro following the path of Lewis Brook to Main Street, with an extension back to the intersection of Route 31 and West Delaware Avenue. This is a crooked path laid out on a flat plane. The figure shows the possible locations of detention (dry) or retention (wet) basins on the Landfill and the Blackwell and Pennington School property. The first 300 feet of the current Lewis Brook, east of Green Street, flows through Pennington School property, so the school would need to be a participant in this flood control project.

Figure A3 shows a Google Earth Pro map with smaller and larger detention basin options for the landfill and the combined Blackwell and Pennington School properties. Part of the cost of excavating the basins would be offset by moving the dirt to expand the area above the flood plain on each property and increase the value of any redevelopment.

In the case of the Blackwell property, it adds about 2.2 acres along Brookside Avenue and Green Street. A recent flood plain analysis showed the developable area on this property was negligible. It should be noted that Mark Blackwell had been approached by PSE&G two years ago about locating an indoor substation where his old barn is. PSE&G offered to pay for a lot of excavation work. This option should be revisited. We will require more electric power in Pennington as our energy sources change and we should be prepared to accept a distribution point in Pennington in return. An interesting anecdote from Mark was that part of his property used to be dammed in the winter to create an ice-skating area.

For the landfill, the benefit would come if the waste were to be removed, and the site returned to greenfield status. The developable area in the southern portion of the landfill would go from close to zero to 3.7 acres. The area adjacent to Broemel Place is not affected by the basins and adds additional acreage for development.

For the two basin options on the landfill, the west sides of both follow the natural rise in the ground from the ditch to the Starbucks and Pennington Shoppes sites, which would form the west edge of each basin without excavation. Several pipes draining areas and buildings to the west come out of this bank and flow into the ditch or the stream. The west side of the larger basin follows the 188-foot contour further north and then turns east where the land rises towards Broemel place. It then turns south along the elevated section by the fire house lot. On the east side, the outline follows the 188 height contour of the landfill back towards Delaware Avenue. A berm across Lewis Brook, with an overflow and choke pipe, would be needed to join the fire house and landfill elevated sections. The larger basin surrounds the location of Well #6, which is currently in use. The smaller basin has a berm, overflow and choke pipe south of the well. After allowing for 30 degree sloping sides, with 5 feet depth, the larger basin will allow detention of 710,000 cubic feet of water, and the smaller basin will allow 470,000 cubic feet.

The elevation of the high-water mark on both basins has been limited to 183 feet to allow drainage from the 185-foot-high intersection of Route 31 and West Delaware Avenue during high rainfall storms. The apron of the Exxon gas station and the parking lot for Uncle Ed's and Borough market also are at 185 feet and need to drain by gravity. The only other option to drain this intersection is towards Jacobs Creek to the south. This would require a large deep culvert over 1900 feet long with an 11-foot elevation change, which is unlikely to work. A new culvert under West Delaware Avenue or the sidewalk is needed. It should be large enough to drain all the water flow into the intersection with significant height clearance to avoid pressure build up and limitation of flow. A 10 x 5 ft cross section should work. The current pipe from the intersection looks like it is about 18 inches in diameter, which is inadequate for a severe storm.

When the culvert installation is being done, we should take the opportunity to widen West Delaware Avenue to allow three westbound lanes, left-turn, straight and right-turn as discussed in the Section 4. This would allow more through traffic on a green light by avoiding the delays from right-turn traffic giving way to pedestrians crossing Route 31. It would use the available right-of-way on the south side of West Delaware Avenue.

Figure A3 also shows two basin options for the Blackwell and Pennington School Properties and possible locations for the new bridge under Green Street, which is in the County design stage. As discussed in Section A1 about the flow capacity of Lewis Brook tunnels, culverts and bridges, I believe the correct solution to eliminate flooding under the Broemel Place railroad bridge is to build the new Green Street bridge to the south of the Broemel Place intersection and divert Lewis Brook to this bridge and away from Broemel Place. The existing undersized bridges under Broemel Place and Green Street can then be segregated from the main Lewis Brook flow and left in place to drain the Broemel-Straube catchment area. The location of the bridge under Green Street affects the design of the catchment basin.

Both the smaller and larger basin options show an extension to the southwest of the existing Lewis Brook channel to allow water from my proposed new bridge location to drain into Lewis Brook by the addition of a new channel. This new channel is needed for the new Green Street bridge regardless of whether a detention basin is built if we wish to eliminate flooding under the Broemel Place railroad bridge. The smaller basin, which is mostly on the Blackwell property, will hold 625,000 cubic feet of water whereas the larger basin, which covers additional Pennington School property, would hold 1,180.000 cubic feet.

In both cases, a retention basin with about 3 feet of water below the choke level could be installed in place of a dry detention basin. These would not reduce the amount of water that can be detained during a storm but, if landscaped, could be attractive ponds and would add to the area of wetlands and the value of the development. The standing water would help to remove sediment and contaminants. Digging out the extra 3 feet for the ponds would increase the amount of fill available for the developable areas and increase their value. Note that the landfill basin options incorporate the detention basin behind Starbucks, which has been classified as wetlands. Adding it to the pond would keep it as wetlands.

A3. The effect of the detention basins on flow rates during a storm

Table A3 shows results extracted from a spreadsheet that models water flow for 9 combinations of large and small Landfill or Blackwell basins. Note that the basins only control the flow as far as Main Street. Much of the Eglantine catchment flow shown in the bottom four cells of column 4 of Table A2 bypasses the Blackwell basin and these are added directly to the Main Street flow.

Table A3. Flow rates with various combinations of basins using the Ida rainfall data.

Landfill basin vol. ft3	0	470K	0	470K	710K	710K	0	470K	710K
Blackwell basin vol. ft3	0	0	625K	625K	0	625K	1180K	1180K	1180K
One hour flow rates									
To CSX Tunnel ft3/sec	381	255	381	255	200	200	381	255	200
To Green St ft3/sec	457	331	457	331	276	276	457	331	276
To Main St ft3/sec	457	331	283	206	276	188	194	151	136
To Eglantine ft3/sec	762	635	588	511	581	492	499	456	441
Two hour flow rates									
To CSX Tunnel ft3/sec	299	233	299	233	200	200	299	233	200
To Green St ft3/sec	358	293	358	293	260	260	358	293	260
To Main St ft3/sec	358	293	283	206	260	188	194	151	136
To Eglantine ft3/sec	597	532	522	445	499	427	433	390	375
Three hour flow rates									
To CSX Tunnel ft3/sec	228	215	228	215	200	200	228	215	200
To Green St ft3/sec	273	260	273	260	246	246	273	260	246
To Main St ft3/sec	273	260	215	206	246	188	164	151	136
To Eglantine ft3/sec	455	443	397	388	428	370	346	333	318
Six hour flow rates									
To CSX Tunnel ft3/sec	144	122	144	122	111	111	144	122	111
To Green St ft3/sec	172	150	172	150	139	139	172	150	139
Volume out ft3/sec	172	150	143	122	139	110	118	96	85
To Eglantine ft3/sec	287	265	258	236	254	225	232	211	200

The model calculates choke flow values at each basin exit to prevent overflow. Since the chokes will not be adjustable in the field, the highest choke value calculated for any of the four flows is used for the other three. For example, for the maximum 1-hour flow, the rain volume from Table A2 columns 1 and 2 was 1,644K cu.ft.. The total volume of the basin in column 8 is 1,650 cu. ft. and in column 9 is 1,890 cu. ft. so both exceed the 1-hour volume and the model calculates that no choke flow is needed from the Blackwell basin. The 3-hour flow volume is 2,950K cu. ft. and this controls the choke value of the Blackwell basin for both columns 8 and 9, and for column 6. The 2-hour flow volume of 2,580 cu. ft. controls the choke value for the Blackwell basin for columns 4 and 7 and also the choke values in all columns with a landfill basin.

Column 1 in Table A4 is the current situation with no detention basins. For the 1-hour peak flow volume, the flow at Main St, is reduced by the two large basins (column 9) to 30% of that without basins and was reduced at Eglantine to 58%. The corresponding numbers for the combination of the small landfill basin and the large Blackwell basin (column 8) are 33% and 60%. The slightly lower reductions may be acceptable since Well #6 could remain in use.

Note that the model is a simple one and would need a hydrology study to develop more accurate numbers. However, I feel this is sufficiently accurate to make decisions about whether any of the suggestions should be followed up.

A4. Downstream from Eglantine Avenue bridge

Additional thoughts for locations downstream of the Eglantine Avenue bridge are as follows:

The proposed new bridge taking Pennington-Rocky Hill Road over Stony Brook should be large enough to ensure that the water from the worst predictable storm can pass under the bridge without flowing over the road deck. Overflow has been experienced in the past.

Further downriver, we should ensure the beavers aren't allowed to build a dam like the one that built up Stony Brook water levels to an extent that threatened the sewage plant control room.

We should consider allowing the rebuilding of the dam that Pennington owns east of the Borough to 138 feet elevation with a choke and overflow to create a retention basin for Stony Brook that would extend upstream beyond the Rocky Hill Road bridge. This could slow down about 500,000 cubic feet flowing towards Princeton during the peak of a storm.

A5. What is Lewis Brook in the Landfill – a ditch or a named stream?

Lastly, to understand the NJ DEP restrictions on development due to riparian zones, floodplains and wetlands, the question of where Lewis Brook runs on the landfill and how it is defined should be answered. Figure A4 is a copy of the 1950 Fire Map that shows that the original route of Lewis Brook was diagonally across the landfill site. Figure A5 is a segment from a 1966 aerial view of Pennington. It is a winter scene and clearly shows the new landfill starting to encroach on the diagonal path of Lewis Brook. Shortly after this, the ditch was dug along the western edge of the property, leading to a small bridge under the access road, which still exists. A continuation of the ditch was dug to the tunnel under the railroad. I contend that since neither of these follow the original path of Lewis Brook, they are man-made and should be classified differently from a stream following its natural course.

In the case of the landfill. We need to weigh the good that comes from clearing the garbage and economic development, including a much-needed detention basin, against the environmental protections afforded a natural stream. Eliminating flooding by elevating the land surrounding the ditch allows development which makes this worthwhile project economically viable.

Similarly with the Blackwell and Pennington School properties, the economic viability of the project depends on creating enough area out of the flood plain for development, in addition to the downstream benefits of a large detention basin.

Appendix B. Drop Pin locations used to determine the catchment areas

1. To the Landfill tunnel
Area plotted: Landfill tunnel to SE corner of Pennington Market, to high spot on Route 31S, to high spot on Morningside Drive, to SE corner of High School front parking lot, to NE corner of High School rear parking lot, to Route 31 at Brandywine, to SW corner of Post Office lot, and back to landfill tunnel.
Area from Google Earth polygon 5,106,000 sq. ft. ~ 5 million sq. ft.

2. To the Broemel Place railroad bridge
Broemel Place bridge to SW corner of Post Office lot, to Route 31 at Brandywine, to high spot on Knowles St, and back to Broemel Place bridge.
Area from Google Earth polygon 866,000 sq. ft. ~ 1 million sq. ft.

3. East of railroad tracks to the Lewis Brook Bridge on Eglantine Avenue
Lewis Brook Bridge to Eglantine Avenue at St. James, to high spot on South Main St, to SW corner of Pennington School football field, north along railroad tracks to old Pennington station, to high spot on North Main St., to high spot on King George Rd, and back to Lewis Brook Bridge on Eglantine Avenue.
Area from Google Earth polygon 3,991,000 sq. ft. ~ 4 million sq. ft.

The total capture area for the three catchment areas feeding Lewis Brook at the Eglantine Avenue Bridge is ~ 10 million sq. ft.

Figure A1. Catchment areas for Lewis Brook west of Eglantine Avenue. Landfill (yellow) ~5 million sq. ft., Broemel Place (pink) ~1 million sq.ft,, Eglantine east of CSX tracks, ~4 million sq.ft. Total ~10 million sq.ft. Lewis Brook is shown in blue.

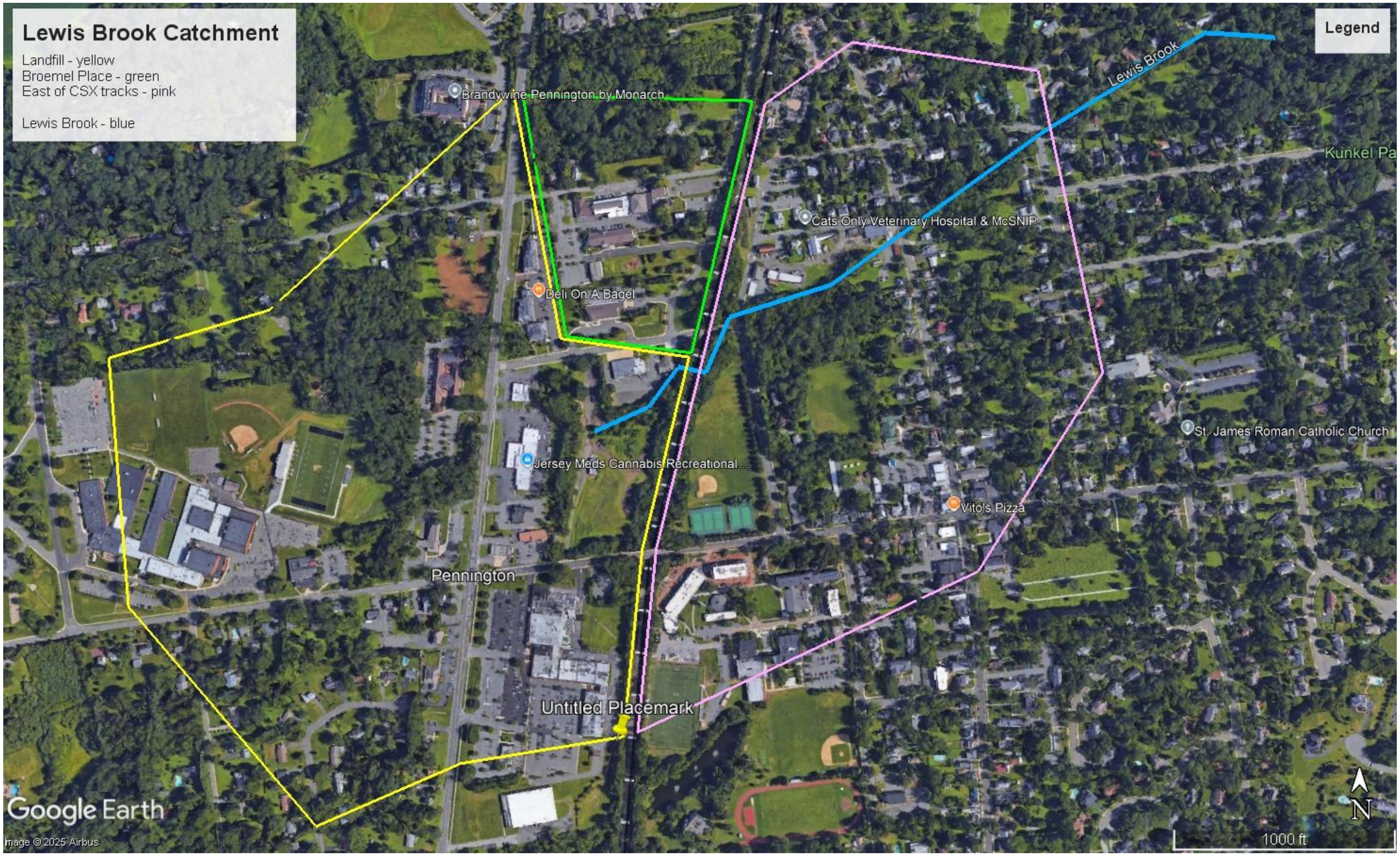

Figure A2. Elevations from the intersection of Route 31 and West Delaware Avenue to North Main Street, showing the track of Lewis Brook and its southern tributary (the ditch) passing through potential detention basins on the Landfill site and the Blackwell and Pennington School combined sites, and the locations of the CSX tunnel and the new bridge options on Green Street.

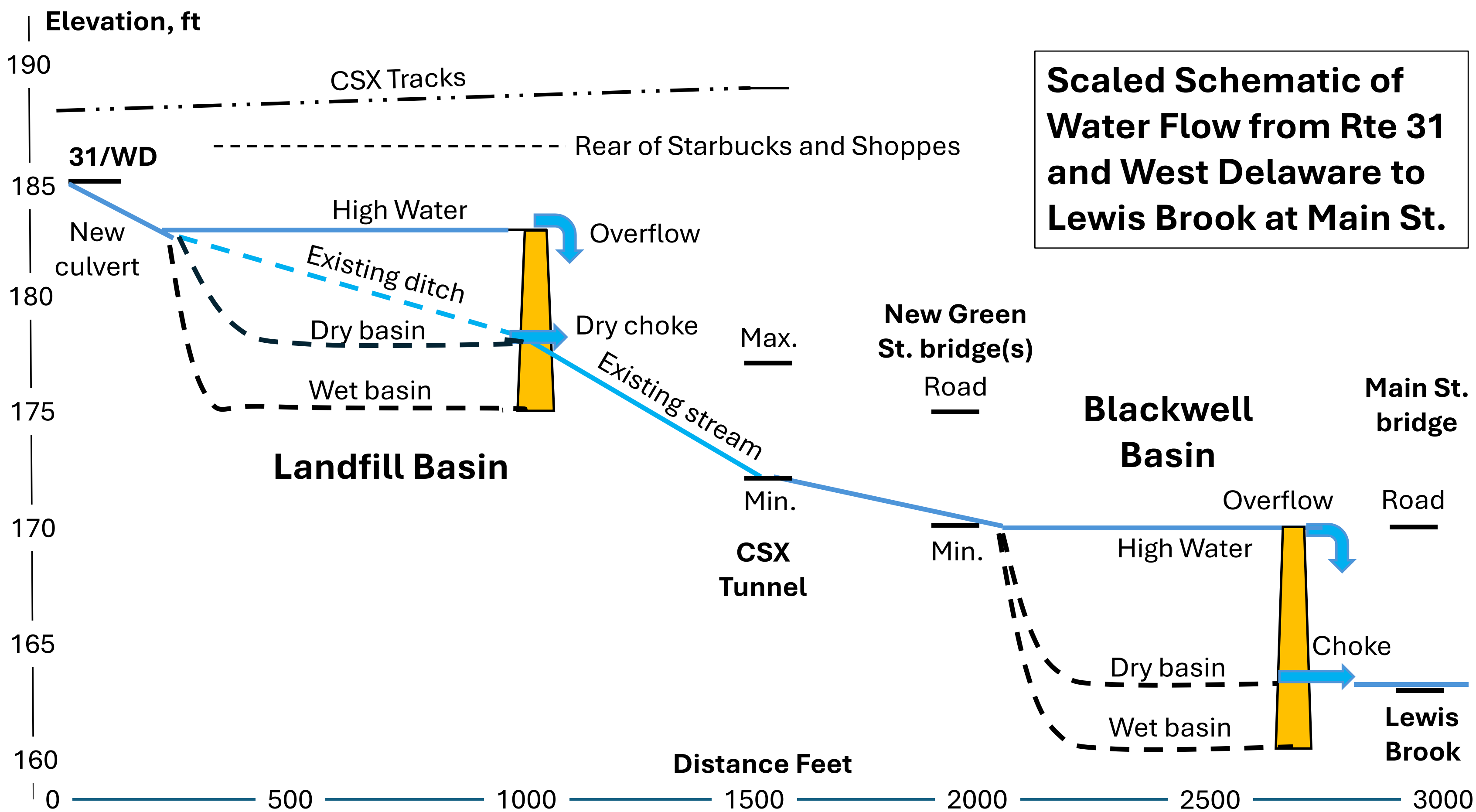

Figure A3. Map showing locations of possible smaller and larger detention basins on the Landfill and the Blackwell and Pennington School combined property. Total stored water volume could be from 1,100,000 to 1,900,000 cubic feet. Alo shown are two new bridge options on Green Street.

Figure A4. The 1950 Fire Map shows that the original route of Lewis Brook was diagonally across the landfill site.

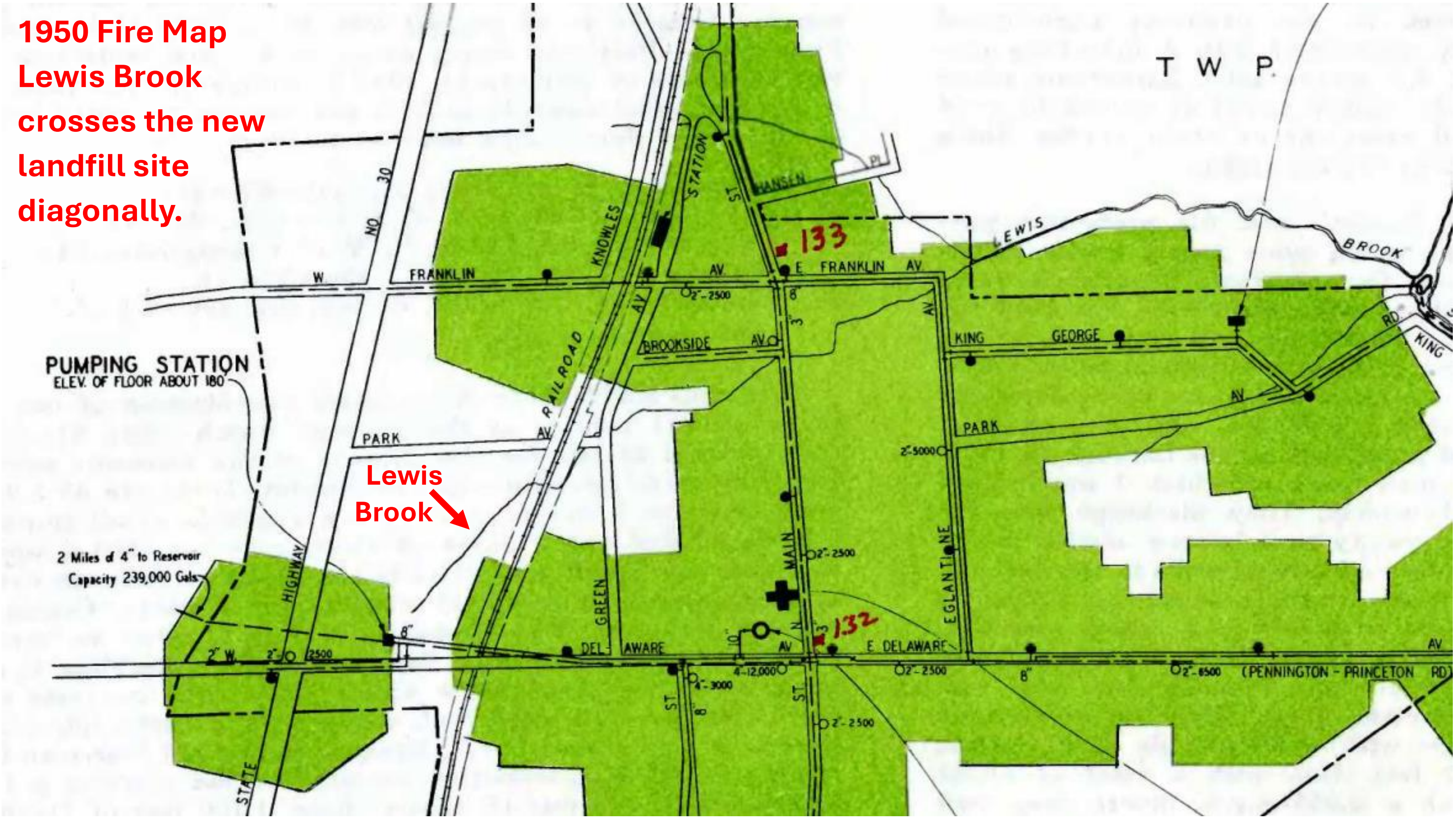

Figure A5. Aerial photo from 1966 - Lewis Brook can be seen crossing the new landfill site diagonally.