5. THE RECOMMENDED PLAN

Alternative 4 is the Locally Preferred Plan (LPP) and the recommended plan. The LPP will provide flood damage reduction for events with an exceedance probability of approximately 1 percent (100-year event). The plan consists of one levee/floodwall system with two sluice gate closure structures on the western side of the Township and a sluice gate closure structure and a limited road raising on the eastern side of Township. The alignment of the line of protection was refined based on physical, environmental, and economic criteria. The optimal alignment was identified by:

- Avoiding and minimizing adverse effects on study area wetlands,
- Following high ground to the extent possible to minimize floodwall/levee costs, and
- Protecting flood-prone structures, which are located in high-density concentrations.

This section of the report describes the design, project costs, and benefits of the LPP.

5.1 Line of Protection Description

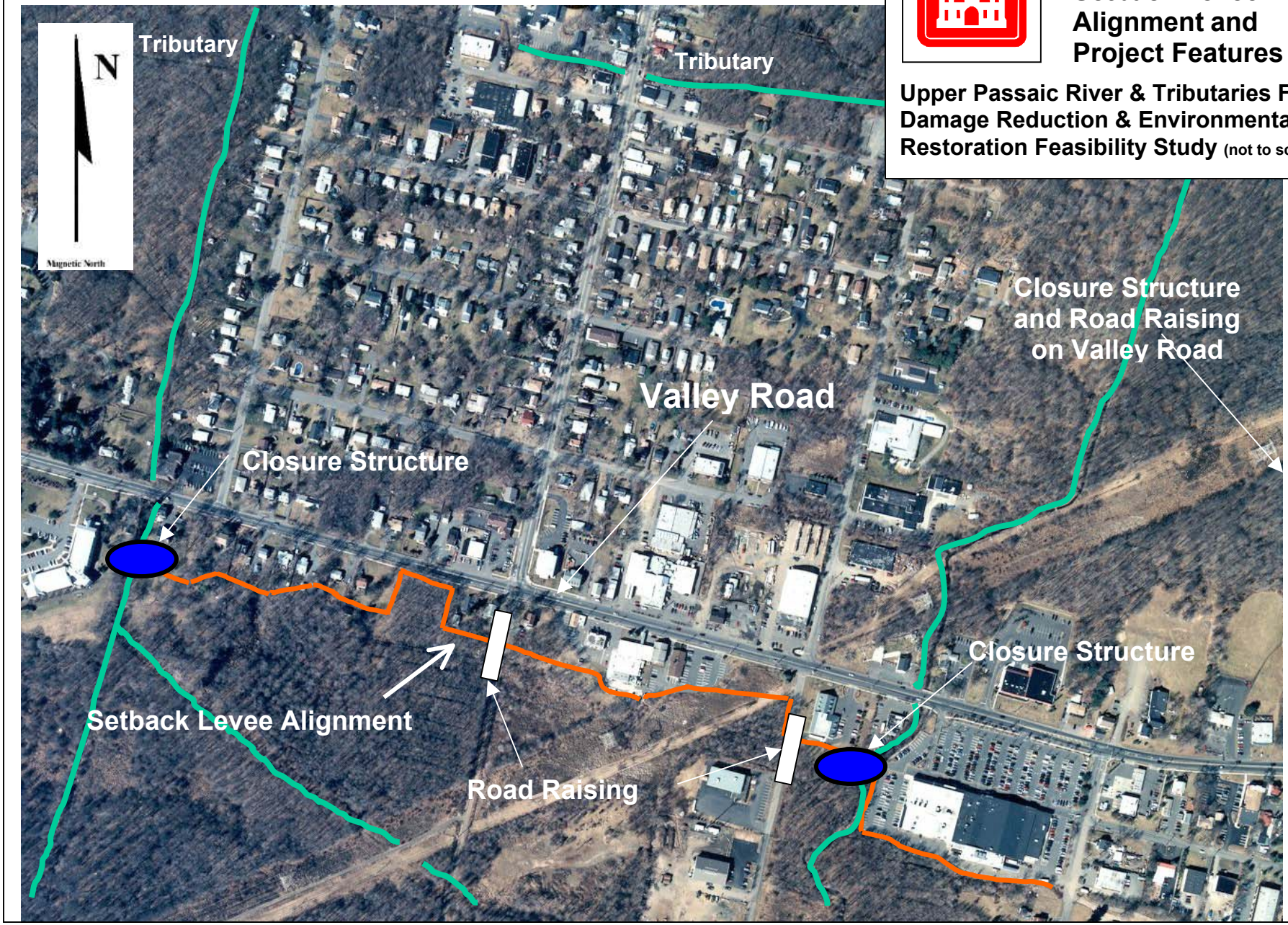
The two elements of the project are designated as: the Western Segment and the Eastern Segment. Because the protected areas are not subject to interior flooding from surface runoff from rainfall, no interior drainage facilities are provided other than drainage swales located along the levee/floodwall. The location of each of the elements and associated features are described below. Figures 5-1, 5-2, 5-3, and 5-4 show the project features. Figure 5-1 is an aerial overview of the alignment, and plan views shown in Figures 5-2 through 5-4 beginning at the westernmost portion of the alignment proceeding to the east.

Western Segment: The Western Segment of the line of protection is located south of Passaic Valley Road and runs roughly parallel Passaic Valley Road between the Loudenberry Meadow Senior Condominium Development and Poplar Avenue. Top of protection is at elevation +216.7 ft and 216.2 ft NGVD, depending on location. The grade elevations along the entire line of protection range between +210.8 and +214 ft. NGVD excusive of the ends. The height of protection above grade ranges between 2.2 feet and 5.4 feet going to 0 feet at either end. The levee section has a 12-ft. wide crest with side slopes of 3 ft. horizontal to 1.0 ft. vertical and a maximum height of 4.5 feet. Due to its relatively low height, no core or cutoff wall is required. The floodwall reaches consist of continuous watertight vinyl or steel sheet pile driven 10 feet into the soil.

The 4,057 linear foot line of protection has a total of 3,996 feet of floodwall and 61 feet of levee. The line of protection begins at Station 0+00 at the northwestern end as a levee starting at a point approximately 280 feet south of Passaic Valley Road in the Loudenberry Meadow Senior Condominium Development. There will be maintenance vehicle access to the top of the levee at this point. The levee then extends in an easterly direction to a stream channel which also corresponds to the edge of the condominium property. The top of levee is at +216.7 NGVD. A sluice gate structure housing a 4ft x 4ft sluice gate in a concrete structure will be located adjacent to the levee, and will extend through the channel to a point approximately 15 feet east of the channel. At the eastern terminus of the first sluice gate, the line of protection continues as a floodwall (selected to minimize damage to wetlands). The wall runs in an easterly direction for

FIGURE 5-1
Setback Levee Alignment and Project Features

Upper Passaic River & Tributaries Flood Damage Reduction & Environmental Restoration Feasibility Study (not to scale)



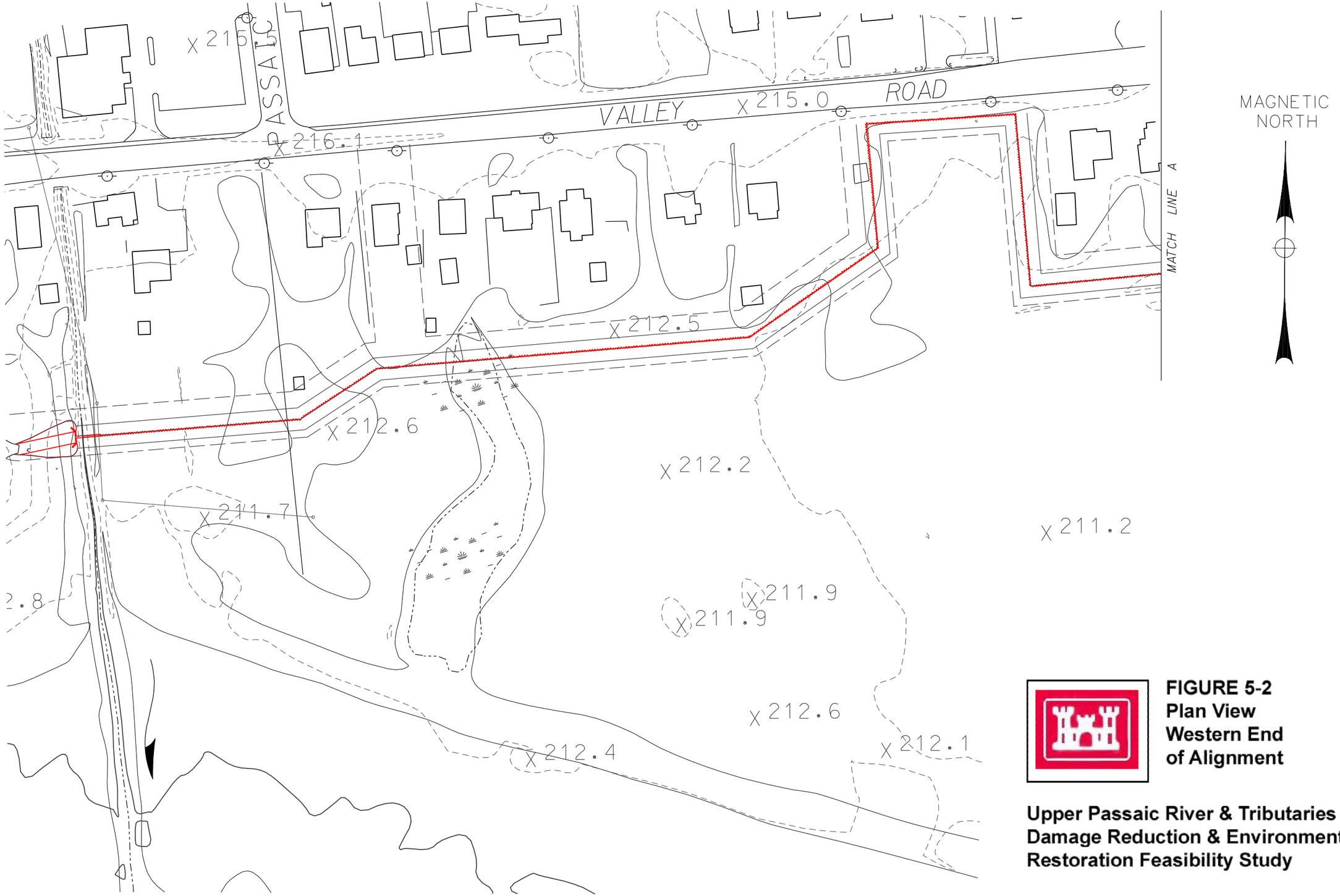


FIGURE 5-2
Plan View
Western End
of Alignment

Upper Passaic River & Tributaries Flood Damage Reduction & Environmental Restoration Feasibility Study

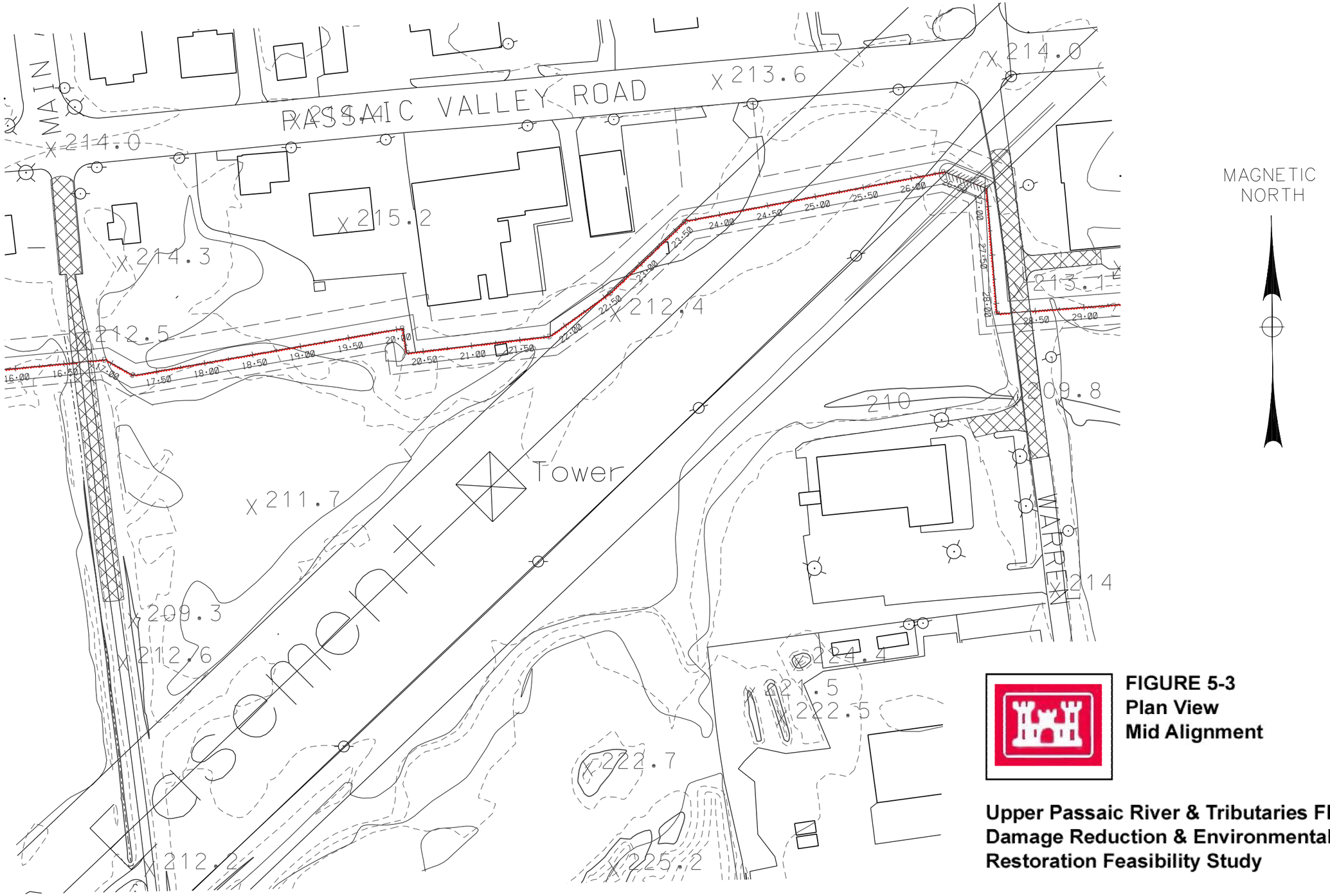


FIGURE 5-3
Plan View
Mid Alignment

Upper Passaic River & Tributaries Flood Damage Reduction & Environmental Restoration Feasibility Study

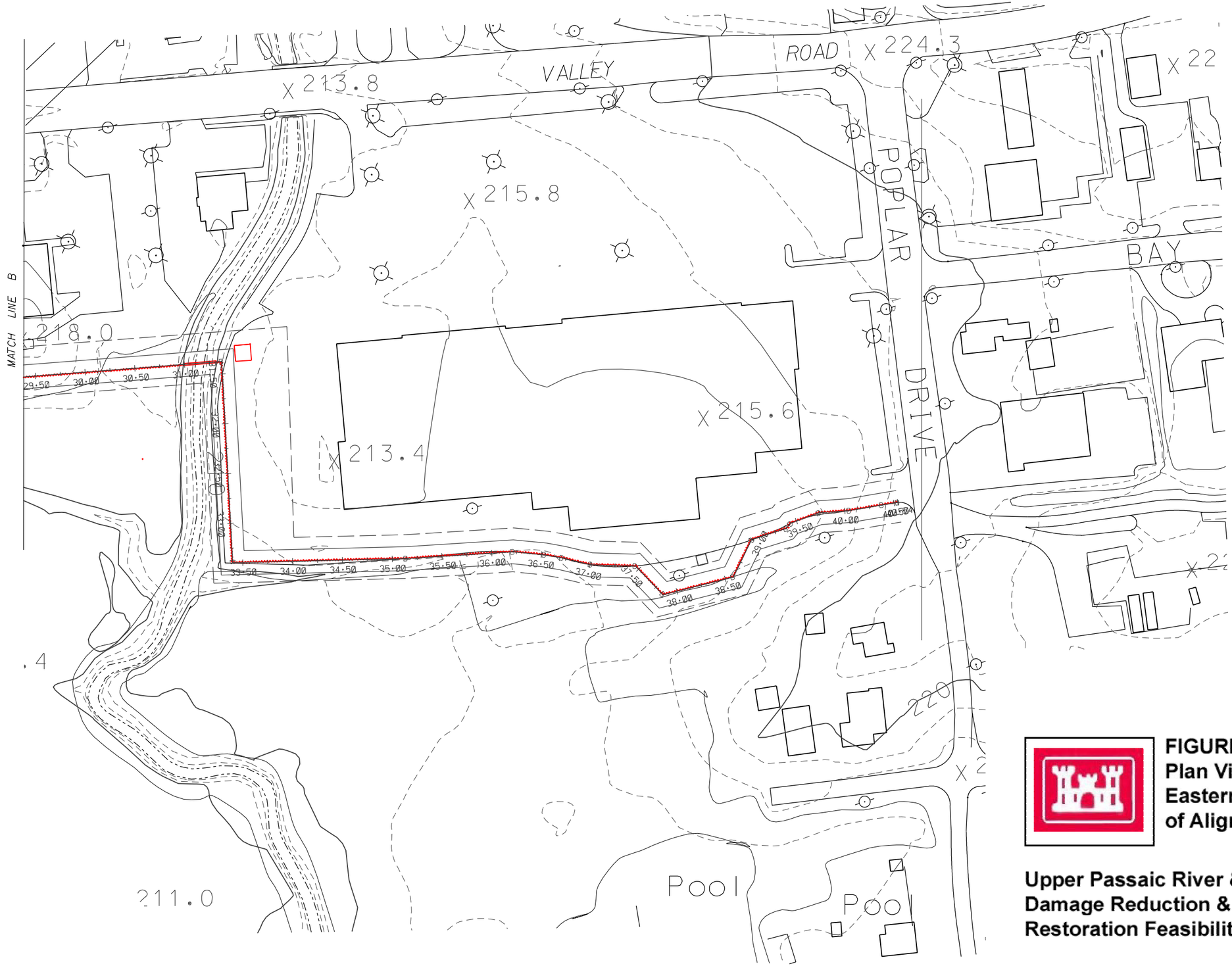


FIGURE 5-4
Plan View
Eastern End
of Alignment

Upper Passaic River & Tributaries Flood Damage Reduction & Environmental Restoration Feasibility Study

approximately 210 feet where it turns to the northeast and continues on for 90 feet. The wall then turns back to an easterly direction for approximately 145 feet before turning back to the northeast for approximately 130 feet then back to an easterly direction for 210 feet. At that point, the wall turns north for approximately 135 feet to a point 15 feet south of Passaic Valley Road. Up to this point, the top of wall elevation is +216.7 NGVD. Upon reaching this point, the wall turns east for 220 feet before turning south. This segment of the wall is at elevation +216.2 NGVD and is an overflow section. After turning south, the wall elevation returns to +216.7 NGVD and continues south for 180 feet then turns east for 245 feet, crossing South Main Street.

At South Main Street, the road is raised to cross over the wall to provide vehicular access. The elevation of the road crossing is +216.2 NGVD. Fifteen feet east of South Main, the wall turns to the southeast for 30 feet before turning back to an easterly direction for 270 feet. At this point, the wall elevation changes to +216.2 NGVD and turns to a southerly direction for 25 feet then turning in an easterly direction for 140 feet. The wall then turns to the northeast for 175 feet then turning in an easterly direction for 265 feet through the PSE&G easement.

Upon entering the Transco Gas Pipeline easement, the wall ends and a 40 foot levee segment crosses the easement, running in a southeasterly direction. The levee segment allows crossing of the pipeline and is at elevation +216.7 to limit damage due to erosion in the event of an overtopping. Upon exiting the easement, the floodwall resumes, and continues in a southerly direction for 125 feet, parallel to Warren Avenue. The wall elevation is +216.2 NGVD. The wall then turns easterly for 270 feet to a 16 foot wide concrete sluice gate structure containing 2 5ft x 7ft sluice gates.

Warren Avenue is raised over the wall to provide access to Municipal facilities south of the wall. The floodwall resumes heading south from the sluice gate structure for 195 feet along the western edge of the supermarket parking lot. The wall then turns in an easterly direction for the final 714 feet, generally following the edge of the parking lot with the exception of a shift to the south to allow the inclusion of an electric transformer.

Eastern Segment: The Eastern Segment of the line of protection is located along Valley Road, east of Western Boulevard. This segment consists of a 12 foot long concrete sluice gate structure on the stream with vinyl or steel sheet piling to tie it into the road embankment. Valley Road is raised to a minimum elevation of +216.2 NGVD to act as a levee. In order to achieve proper roadway vertical curve geometry, 780 feet of Valley Road will be repaved, along with portions of two driveways and a parking area.

5.2 Levee Design

The height of the levee will vary from one to five feet. A five foot high typical levee structure with 3H:1V side slopes and a 15 feet wide top was analyzed for slope stability using the STABL program. Rapid draw down conditions were assumed for the worst-case hydrologic conditions, although these conditions may be unrealistically conservative for typical flooding which is likely to be too brief to fully saturate the embankment. The preliminary location of the levee is between Station 0+00 and Station 3+50. Seepage below the levee will be negligible because of the low permeability clay foundation. Seepage through the levee will also be negligible if locally available clay borrow is used. Engineered fill consisting of clay typical of the area was the assumed embankment material. The simulated conditions yielded a global factor of safety of 3.1

under static conditions, well above the required 1.5 factor of safety generally required for embankments.

5.3 Floodwall Design

Vinyl or steel sheet piling, driven by means of a protective mandrel, was evaluated for use as a floodwall structure. Actual wall height will vary from one foot to a maximum of five feet.

The section analyzed consisted of a five feet high freestanding wall segment, reaching from the ground elevation of +212 NGVD to a top-of-wall elevation at +217 NGVD. The buried segment of the wall penetrates to eleven feet below the assumed ground surface to a tip elevation of +201 NGVD. The water level was assumed to be at the top-of-wall for the simulated worst-case conditions, using the properties of 950 vinyl sheet piling in the failure analysis. The maximum moment induced on the sheet piling was well within the allowable range. With an embedment depth of 10.8 feet, the deflection of the freestanding segment, with no tiebacks, was slightly over 1.0 inches. A typical retaining wall section and the extent of the proposed floodwall structure and associated calculations are provided in the Geotechnical Appendix of this Feasibility Report.

To prevent leakage in the joints between the sheeting, a gasket or sealant can be used. Hydrophilic sealers are applied before pile installation and expand when in contact with water. The longevity of these sealers needs to be investigated further in the PED phase.

Given the relatively low height of the levee/floodwall, it is not expected that its presence will block the viewshed. In addition, wooden fencing will be installed along the dry side of the floodwall in order to provide a less obtrusive view of the structure, and maintain the residential character of the project area.

5.4 Geotechnical Analyses

A Test Drilling Program was performed on 29-30 October 2002, in which eight (8) test borings were completed along the proposed levee/floodwall alignment, totaling 179 lineal feet (specific locations and test boring records are provided in the Geotechnical Appendix). The boring depths varied from 14.0 to 25.0 feet. Continuous and representative samples of each soil type were collected in a clear plastic liner for general examination and laboratory testing. Groundwater depths, if encountered, were noted on the test boring records. Test borings were backfilled with bentonite and cement upon completion, and no undisturbed samples were taken for this phase of the project.

Topsoil was absent in three (3) borings, reached a maximum of 1.0 ft in an additional boring. One boring encountered 0.5 ft of buried topsoil, classified as Peat, at a depth of 2 feet. Glacio-lacustrine deposits, sediments deposited from glacial Lake Passaic, were encountered in all of the borings and ranged from 7.0 ft thick to at least 25.0 ft thick (total depth of boring) in three additional borings. The glacio-lacustrine deposits were described as either silt, silty clay or clay. A notable change in color of the glacio-lacustrine deposit occurred between depths of 13.5 and 17.5 feet three borings. The soil changes from a reddish brown, above, to gray and grayish brown, below. The reddish brown soils ranged from medium stiff to hard, whereas the gray and grayish brown soils ranged from soft to very stiff. The average range of consistency of the soils was stiff to very stiff. Moisture contents varied from moist to wet, with an average condition as moist.

5.5 Hydrology and Hydraulics

The hydrology and hydraulics were reviewed and modified for the with-project floodwall/levee conditions, existing watershed conditions. The with-project flood plain is shown on Figure 5-5. The top of the floodwall is at the 100-year water surface elevation of 216.2 (the 100-year WSELs actually vary between 216.3 on the upstream end to 216.1 on the downstream end which will be accounted for in final design). A HEC-HMS model was developed to measure the impact of removal of the flood plain storage behind the floodwall (approximately 1,490 acre-feet) for floods up to the 100-year event. (the storage removed is approximately 4.35 % of the total runoff volume from the 100-year storm). Resulting increases in discharge vary between 2-3% downstream of Stirling. These higher discharges were incorporated in a HEC-RAS model which confined the flow to south of the floodwall (revised effective flow area) and resulted in maximum 100-year water surface increases of 0.1 feet which meets New Jersey Department of the Environment allowable increases for encroachment in the flood plain.

Because there is no freeboard on the floodwall, it can not be said with any certainty that the floodwall will prevent flooding from the 100-year event. Therefore, it may not be credited as providing protection from the base flood shown on FEMA's Flood Insurance Rate Maps.

For future watershed development based on a 2050 planning period, it is expected that 100-year flood elevations will increase flood by 0.1 to 0.2 feet. Therefore, the level of protection provided by the floodwall is not expected to be seriously compromised in the future. If desired, the top elevation of the floodwall can be increased by this amount without any significant costs to the project.

For the with-project condition (floodwall), Passaic River floodwaters will be allowed to enter into the interior drainage areas through the opened sluice gates to flood wetland areas up to the 3-year Passaic River flood level of 211.0. The flood warning system will be used help in making decision about opening or closing the sluice gates by estimating determine the severity of an occurring event. If it is predicted that a storm will significantly exceed the 3-year event, then the sluice gates must be closed immediately to reserve storage of interior runoff. During periods of dry weather, the sluice gates could be closed to pond water from interior runoff to help hydrate the wetlands in the interior areas.

5.5.1 Interior Runoff

Several small tributaries drain through the study area and flow into the Passaic River. The upstream drainage boundaries of these tributaries are Long Hill Ridge. These tributaries do not have large drainage areas (1 to 2 square miles). Rainfall on Long Hill runs off quickly, discharging into low-lying areas at the base of Long Hill to the east and west of the central Stirling business district. Channels currently exist that interconnect the low-lying areas, allowing stormwater to "mix" from several of the tributaries during heavy rainfall events.

Valley Road acts as a barrier to local stormwater flowing to the Passaic River. Tributaries discharge to three culverts that pass the local storm flows beneath Valley Road. These tributaries continue 1,000 to 2000 feet below Valley Road to the Passaic River in small natural channels. An additional culvert under Mountain Road conveys tributary flow east to the Passaic River.

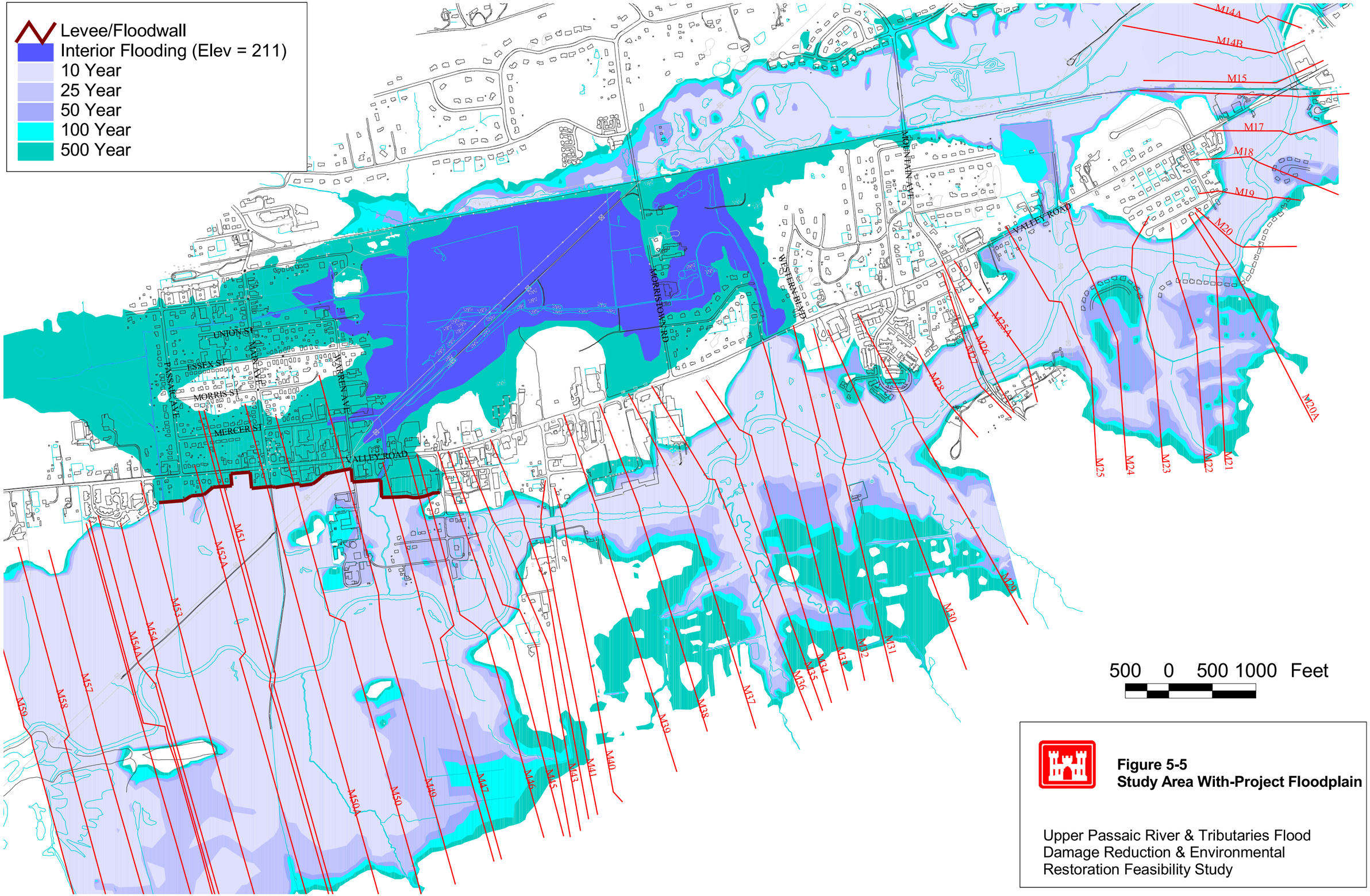


Figure 5-5
Study Area With-Project Floodplain

Upper Passaic River & Tributaries Flood Damage Reduction & Environmental Restoration Feasibility Study

The timing of interior drainage with flooding on the Passaic River is an important factor. Local officials report that coincident flooding is likely. However, given the large drainage area and long time of concentration of the Passaic River (84 square miles) compared to the relatively small drainage area and short time of concentration of the tributaries (1 to 2 square miles), coincident flooding appears unlikely. Further, runoff from the upper Passaic River basin will be attenuated by the large storage volume in the Great Swamp. This will further delay and attenuate the peak discharge on the Passaic River. The local floodwaters coming off of Long Hill are attenuated in the low-lying areas at the base of the hills.

Hydraulic analyses (see Appendix A) determined that interior runoff in the absence of tailwater from the Passaic River does not cause flooding. The analyses also showed that the peak flow in Passaic River near Stirling occurs about 24 hours after the initiation of rainfall. The peak stage occurs on the Passaic about 60 hours after rainfall.

The analyses demonstrated that minimum facilities would be sufficient for interior drainage. The interior elevation peaks at about 24 hours, and takes up to 55 hours to recede for the condition of no tailwater - the interior water surface elevations will have receeded by the time the Passaic River peaks. The strategy outlined in EM 1110-2-1413 follows the premise that interior facilities will be planned and evaluated separately from the line-of-protection, and should provide adequate drainage at least equal to that of the existing infrastructure. The LPP as designed represents the minimum drainage facilities required to implement the line-of-protection plan.

5.5.2 Interior Drainage

The interior drainage facilities were planned and evaluated separately from the line-of-protection in accordance with Engineering Manual (EM) 1110-2-1413, *Hydrologic Analysis of Interior Areas*. First, the minimum drainage facility plan or minimum facilities plan was identified. The minimum facilities are the starting point from which additional interior drainage facilities were compared. The EM states that the minimum facilities should provide interior flood relief such that during low exterior stages, the storm drainage system will function as it did without flood protection in place. The minimum facilities represent the drainage conditions required so that no flooding is induced by construction of the line-of-protection.

Closure structures are necessary to control backflow from the Passaic River beyond the line-of-protection. Under normal conditions the closure structures will remain open and the tributaries will drain normally. During times of Passaic River flooding, the tributary closure gates will be closed to prevent backflow from the Passaic River behind the line-of-protection. Closed control structures will trap local runoff behind the line-of-protection.

An analysis was performed of the interior drainage with the floodwall in-place. The analysis showed that the 50- and 100-year interior flood elevations without any pumping or gravity drainage are 211.5 and 211.9, respectively. The pump requirements to lower the interior flood elevations to the elevation where interior damages begin (211.0) for the 50- and 100-year are 25 cfs (11,220 gpm) and 55 cfs (24,685 gpm), respectively. Both these analyses (with and without pumping) assume no gravity outflow. In reality, the interior drainage runoff nearly always peaks before the Passaic River peaks allowing some gravity drainage before the river stages are too high to allow gravity drainage. Therefore, these numbers (interior flood elevations and pumping requirements) are conservatively high. To provide facilities for local improvements, a small

concrete pad will be provided at one or more of the sluice gate locations to accommodate portable pumps.

5.6 Real Estate

As described in the Real Estate Plan (Appendix G) and summarized in Table 5-1, the estimated total acreage required for the LPP is approximately 18 acres, comprised of approximately 25 affected tracts and 18 affected ownerships. Costs were estimated using a April 2003 valuation (Gross Appraisal). Project real estate requirements would be met using permanent easements and fee simple purchase. Mitigation real estate requirements[2] would be met via fee simple purchase.

Table 5-1
Lands, Damages and Relocations

Permanent Easement	1.554 acres	$ 15,100
Temporary Easement (for construction)	2.933 acres	$ 52,200
Severance Damages		$ 26,800
Fee Simple Purchase (for mitigation)	13.14 acres	$ 79,200
Subtotal	17.92 acres	$ 173,300
Facility Relocations (Road Raisings to act as closure structures)		$ 163,738
	Administrative Costs	$ 151,100
Contingency (25% of lands & damages and administrative costs)		$122,035
	Total (17.92 acres)	**$610,173**

5.7 Economics of the LPP

A detailed cost estimate was developed for the LPP using the Microcomputer Aided Cost Engineering System (MCAES) program. Project implementation costs include: pre-construction engineering and design (PED); real estate acquisition; project construction; construction management / supervision and administration (S&A); wetlands mitigation; cultural mitigation; escalation; and contingencies. A summary of the cost estimate for the LPP is provided in Table 5-2. The change in costs for the LPP from those shown in Table 3-6 reflect the final feasibility level design and MCACES cost estimate prepared for the LPP. The detailed MCACES cost estimate is included in the Cost Engineering Appendix provided with this report. The costs of the LPP and mitigation plan are summarized below.

[2] While land requirements for mitigation are introduced here, the mitigation plan is part of Section 6: Environmental Consequences

Table 5-2
MCACES Cost Estimate – Locally Preferred Plan

Item	Cost	Contingencies	Total Cost
01 Lands & Damages	324,400	81,100	405,500[3]
02 Roadway Relocations	163,700	40,900	204,600
03 Mobilization & Site Prep	234,000	58,400	292,400
06 Wetlands Mitigation	325,600	81,400	407,000[4]
11 Levees and Floodwalls	1,579,300	394,900	1,974,200
15 Tributary Closures	437,600	109,400	547,000
30 Engineering and Design	750,000	187,500	937,500
31 Construction Management	300,000	75,000	375,000
Total Cost of LPP	4,114,600	1,028,600	5,143,200

Table 5-3 shows the project economic summary for the LPP. The plan has total average annual costs of $ 319,560, total average annual benefits of $576,600, a benefit-cost ratio of 1.8 to 1, and annual net benefits of $ 257,040.

[3] Includes $119,700 for NJDEP compensatory mitigation real estate requirements, which are not considered part of Total Project Costs. See Section 6.15 for a discussion of mitigation requirements.
[4] Includes $203,250 for NJDEP compensatory mitigation construction costs, which are not considered part of Total Project Costs. See Section 6.15 for a discussion of mitigation requirements.

Table 5-3
Project Economic Summary for the LPP
April 2003 Price Level, 5.625% Discount Rate
50 Year Period of Analysis

Costs	
Total Costs	$ 5,143,200
Less: NJDEP Compensatory Mitigation[5]	$ 322,950
Total Project Costs	$ 4,820,250
Interest During Construction[6]	$ 160,030
Total Investment Costs	**$ 4,980,280**
Annualized Investment Costs	$ 299,560
Annual Operations & Maintenance Costs	$ 20,000
Total Average Annual Costs	**$ 319,560**
Benefits	
Residential Damage Reduction	221,100
Non-Residential Damage Reduction	290,500
Emergency Savings	16,800
Transportation Cost Savings	48,200
Total Average Annual Benefits	**576,600**
Benefit to Cost Ratio	**1.80**
Net Benefits	**257,040**

[5] See Section 6.15.1 for a discussion of mitigation requirements.
[6] Calculated on Total Project Costs, which are equal to Total Costs minus NJDEP compensatory mitigation costs.