

A Presentation

Post-Construction Stormwater  
Management Workshops  
NOVEMBER - DECEMBER 2004

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# A Case Study

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*...From Planning  
Through Design*

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McMAHON ASSOCIATES, INC.

*Prepared by:*

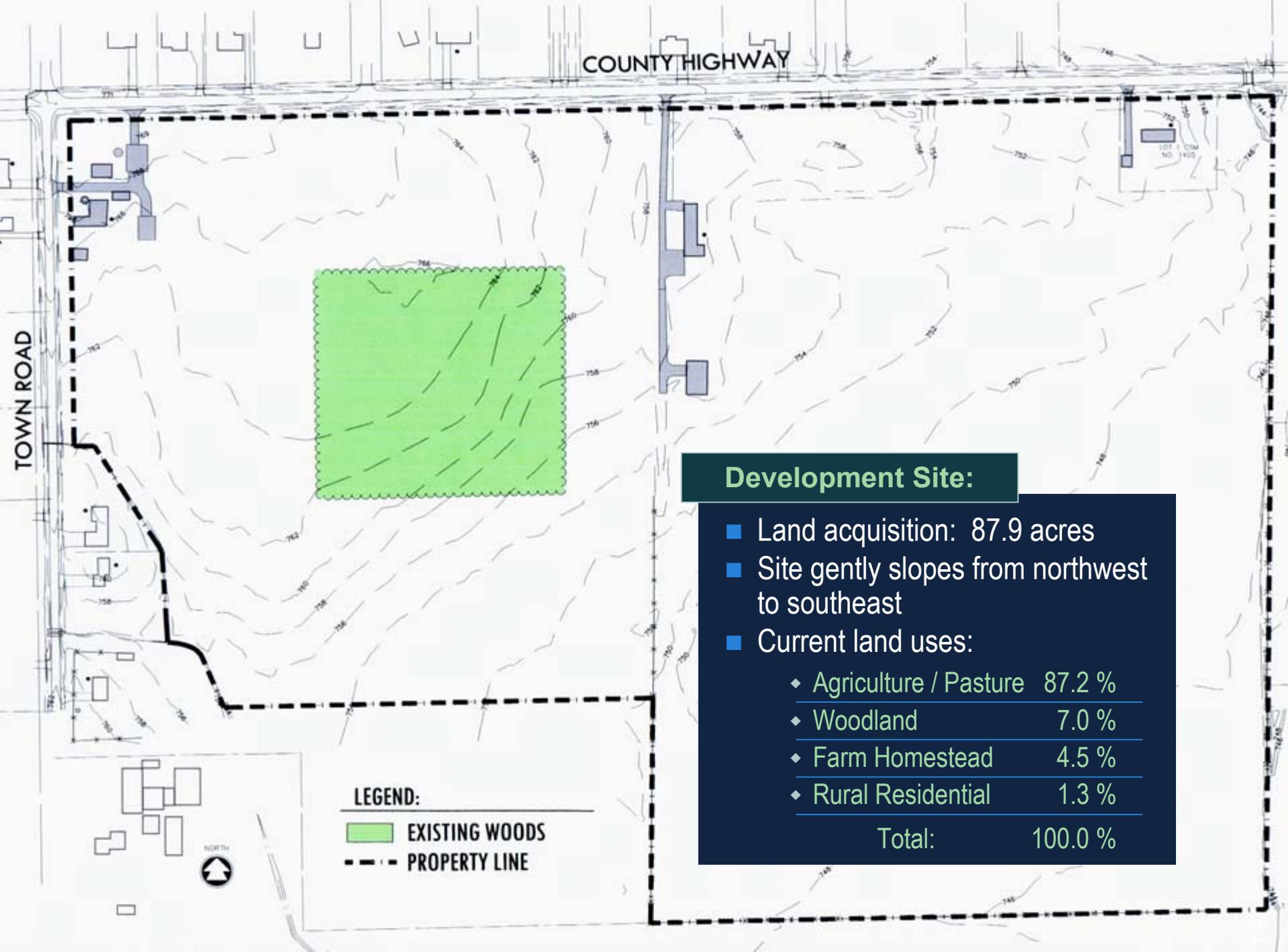
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COUNTY HIGHWAY

TOWN ROAD

LEGEND:

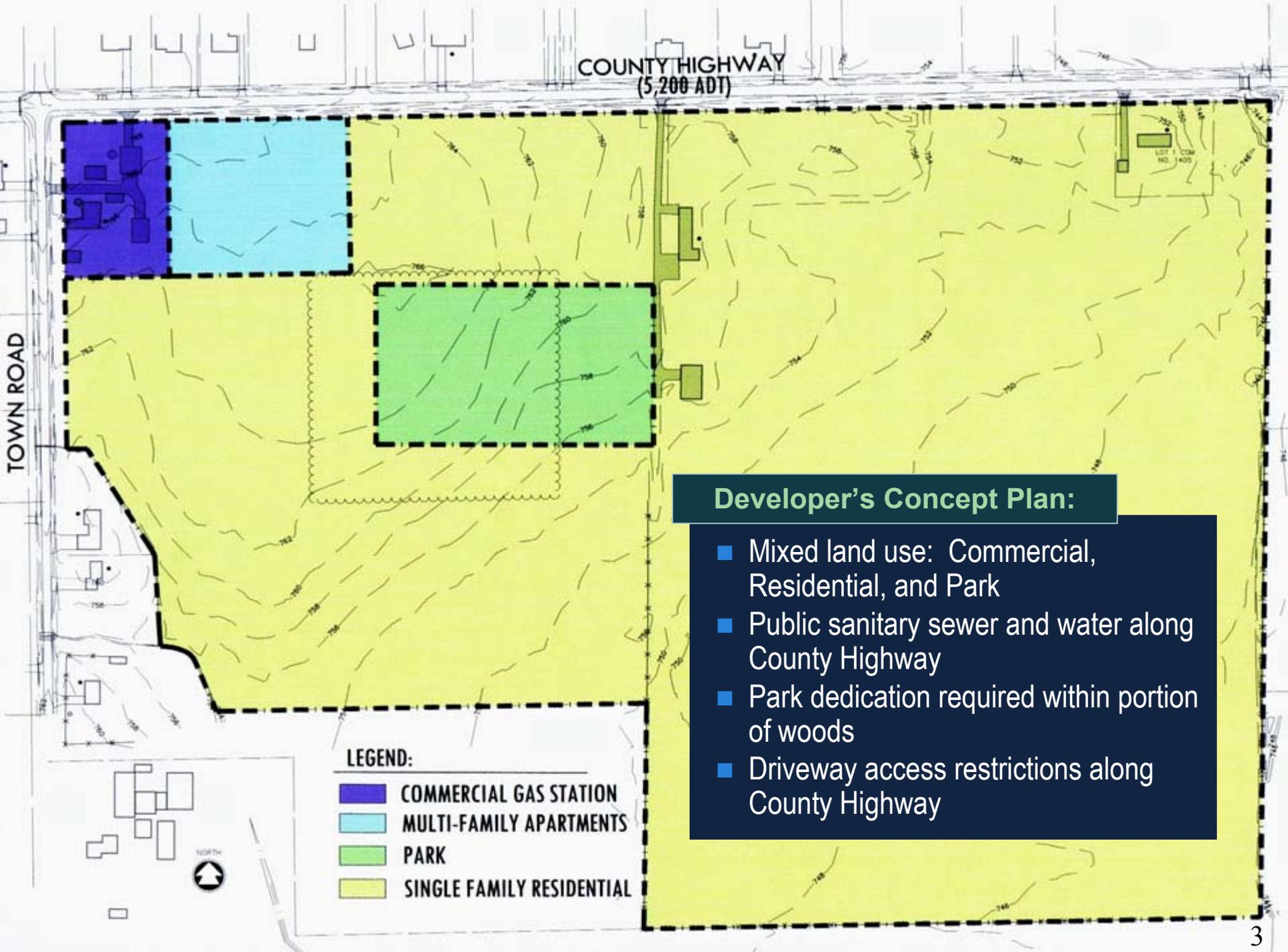
-  EXISTING WOODS
-  PROPERTY LINE

**Development Site:**

- Land acquisition: 87.9 acres
- Site gently slopes from northwest to southeast
- Current land uses:
  - ◆ Agriculture / Pasture 87.2 %
  - ◆ Woodland 7.0 %
  - ◆ Farm Homestead 4.5 %
  - ◆ Rural Residential 1.3 %
  - Total: 100.0 %

COUNTY HIGHWAY  
(5,200 ADT)

TOWN ROAD

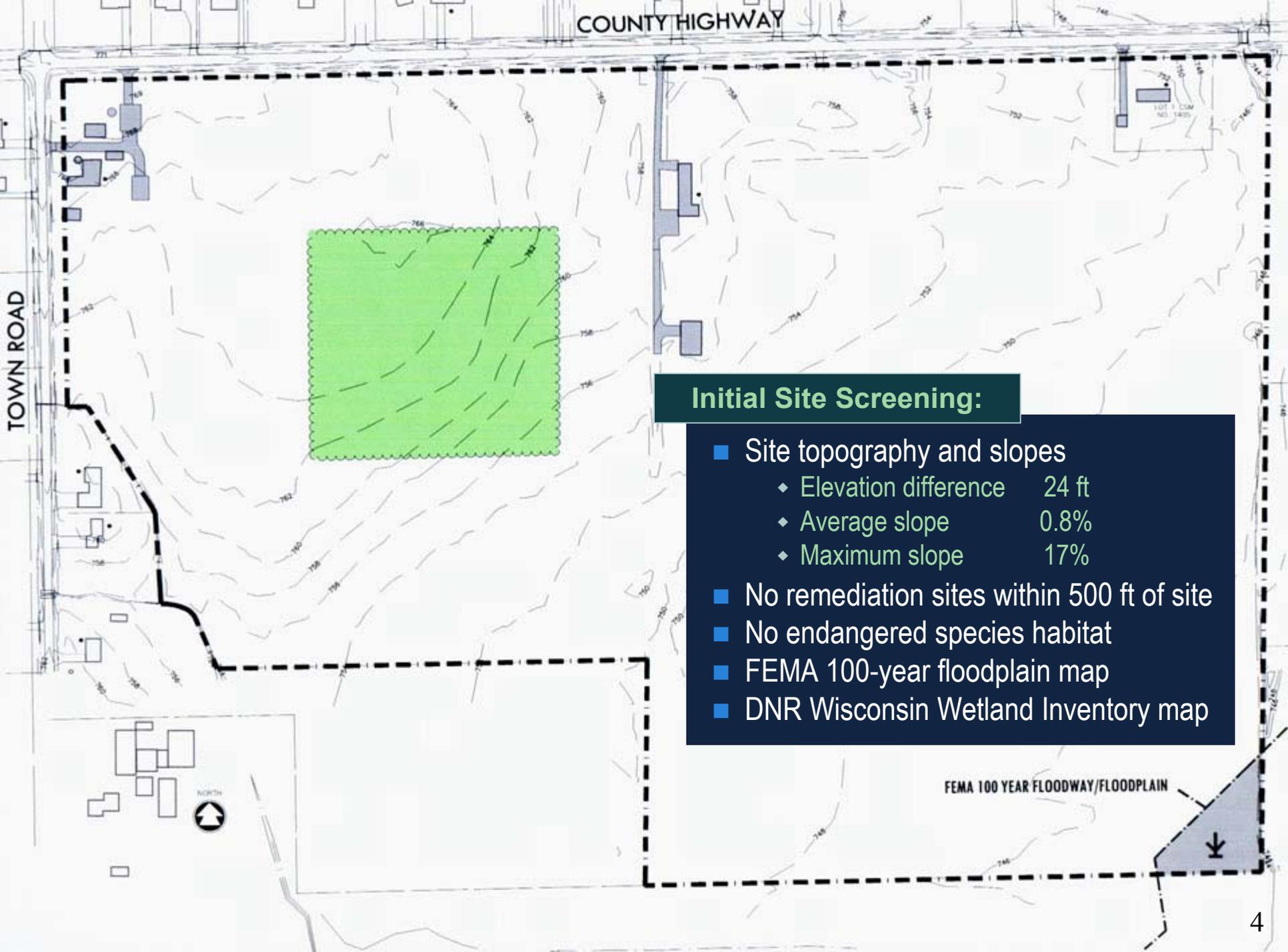


### Developer's Concept Plan:

- Mixed land use: Commercial, Residential, and Park
- Public sanitary sewer and water along County Highway
- Park dedication required within portion of woods
- Driveway access restrictions along County Highway

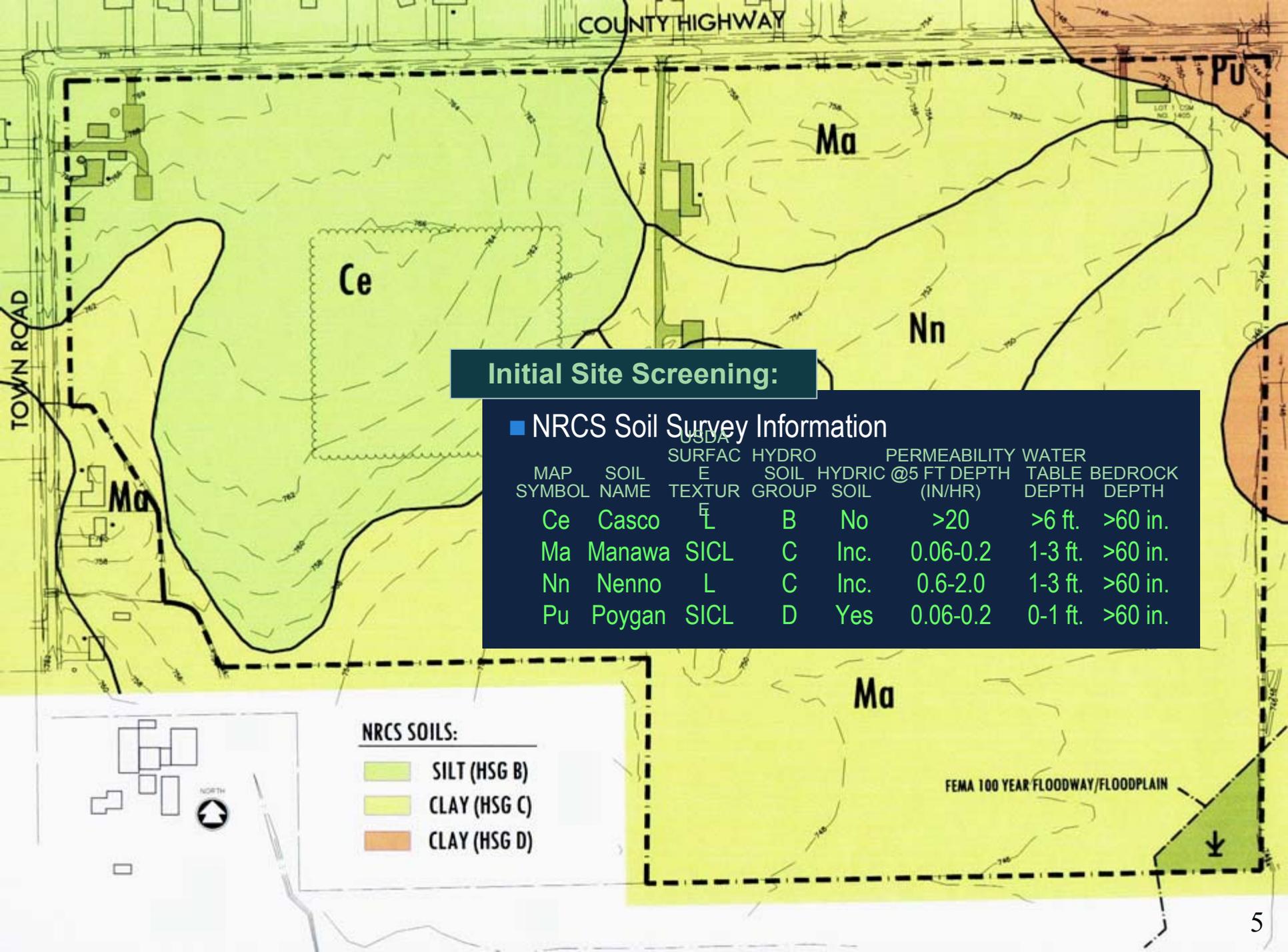
#### LEGEND:

- COMMERCIAL GAS STATION
- MULTI-FAMILY APARTMENTS
- PARK
- SINGLE FAMILY RESIDENTIAL



### Initial Site Screening:

- Site topography and slopes
  - ◆ Elevation difference 24 ft
  - ◆ Average slope 0.8%
  - ◆ Maximum slope 17%
- No remediation sites within 500 ft of site
- No endangered species habitat
- FEMA 100-year floodplain map
- DNR Wisconsin Wetland Inventory map



### Initial Site Screening:

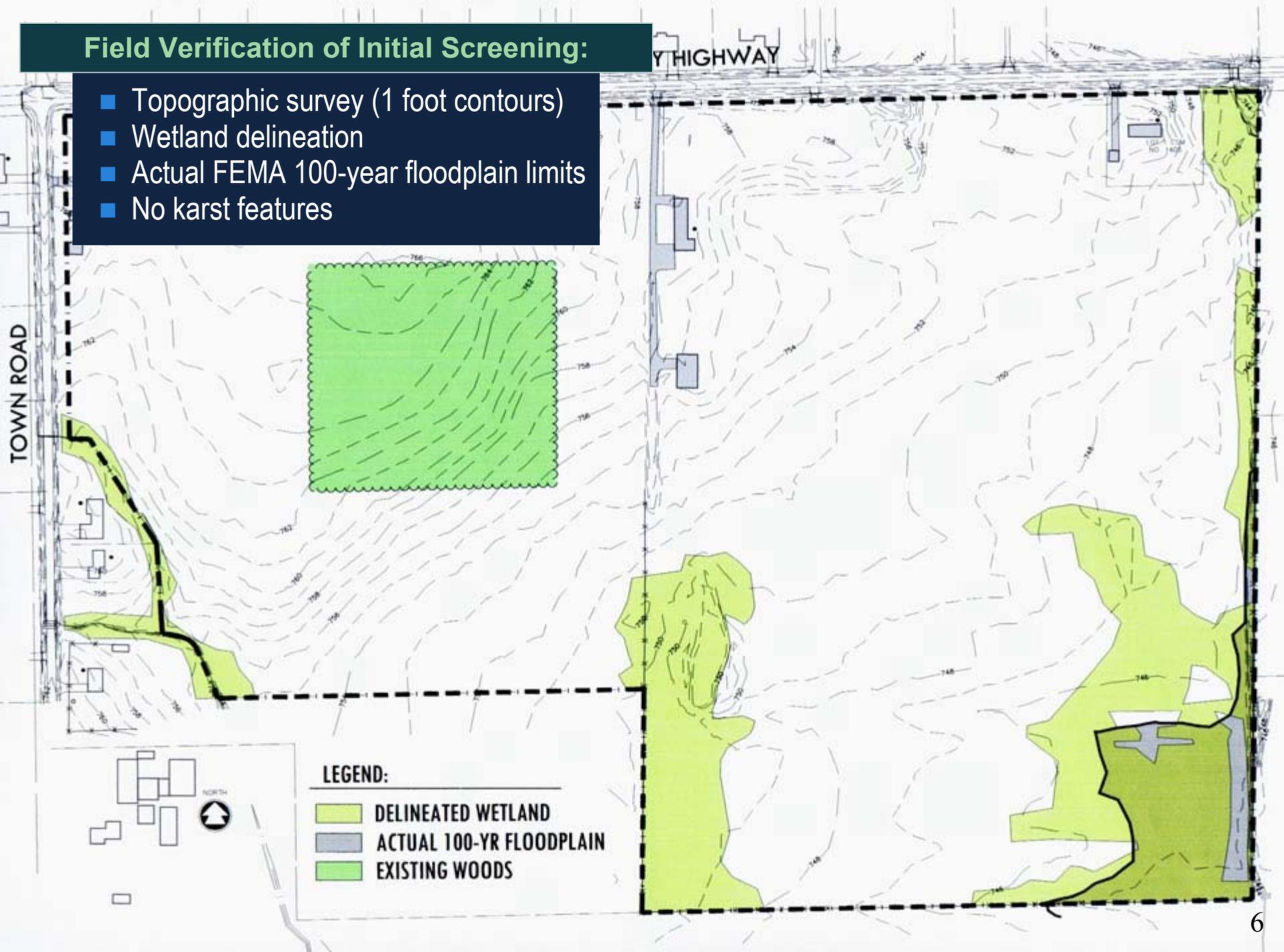
■ NRCS Soil Survey Information

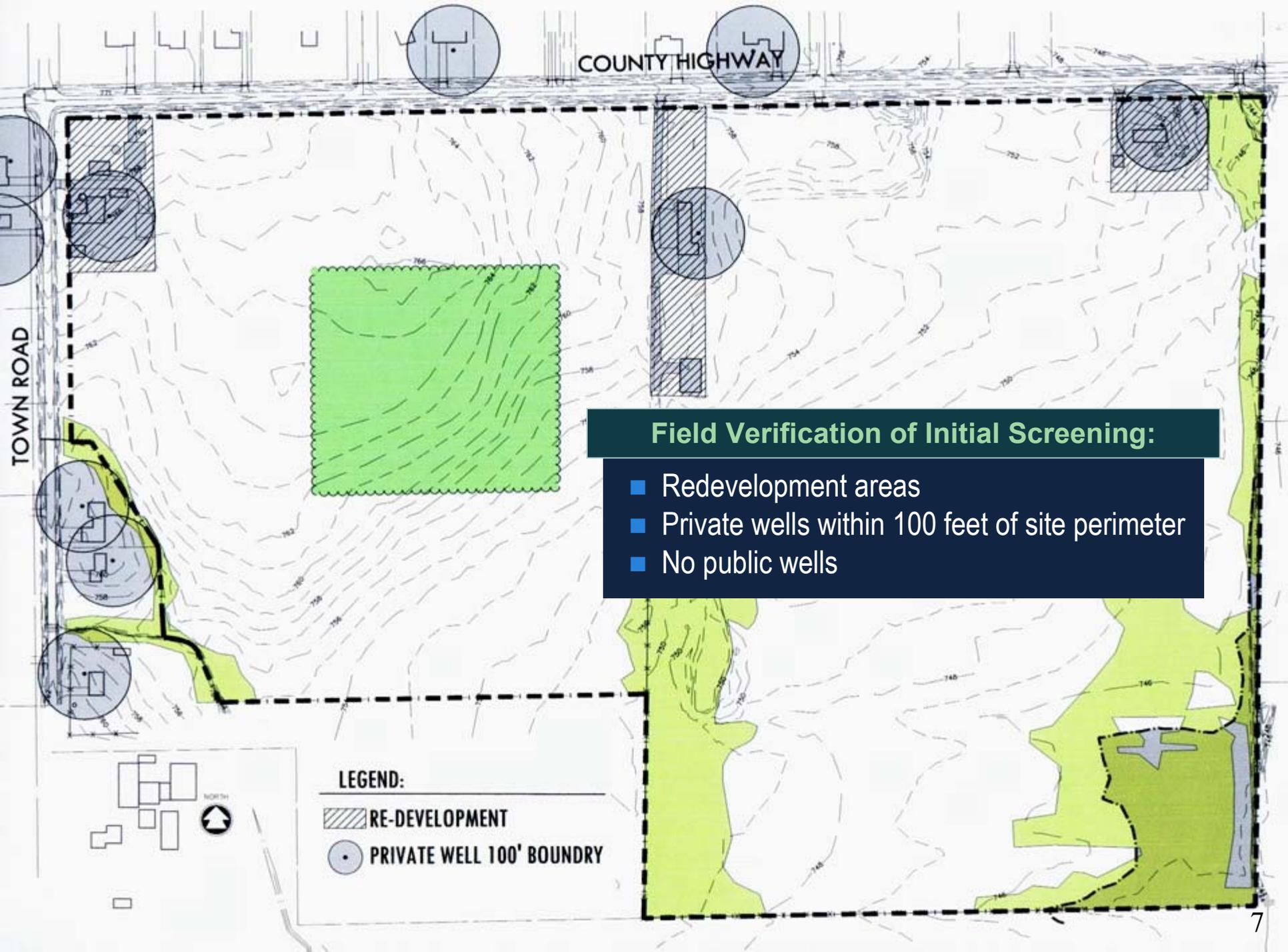
MAP SYMBOL	SOIL NAME	USDA SURFAC E TEXTUR	HYDRO SOIL GROUP	HYDRIC SOIL	PERMEABILITY @5 FT DEPTH (IN/HR)	WATER TABLE DEPTH	BEDROCK DEPTH
Ce	Casco	L	B	No	>20	>6 ft.	>60 in.
Ma	Manawa	SICL	C	Inc.	0.06-0.2	1-3 ft.	>60 in.
Nn	Nenno	L	C	Inc.	0.6-2.0	1-3 ft.	>60 in.
Pu	Poygan	SICL	D	Yes	0.06-0.2	0-1 ft.	>60 in.

- NRCS SOILS:**
- SILT (HSG B)
  - CLAY (HSG C)
  - CLAY (HSG D)

## Field Verification of Initial Screening:

- Topographic survey (1 foot contours)
- Wetland delineation
- Actual FEMA 100-year floodplain limits
- No karst features





COUNTY HIGHWAY

TOWN ROAD

**Field Verification of Initial Screening:**

- Redevelopment areas
- Private wells within 100 feet of site perimeter
- No public wells

**LEGEND:**

- ▨ RE-DEVELOPMENT
- PRIVATE WELL 100' BOUNDRY

COUNTY HIGHWAY

0-1.5' LOAM  
1.5' - 3' SANDY CLAY LOAM  
3' - 4.5' GRAVELLY SANDY LOAM  
4.5' - 10' GRAVELLY COARSE SAND

0-2.5' SANDY CLAY LOAM  
2.5' - 10' GRAVELLY SANDY LOAM

0-3.0' SILTY CLAY LOAM  
3.0' - 5.0' SILTY CLAY

**Field Verification of Initial Screening:**

- On-site soil textures
- No bedrock encountered

COUNTY HIGHWAY

0-1.5' LOAM  
1.5' - 3' SANDY CLAY LOAM  
3' - 4.5' GRAVELLY SANDY LOAM  
4.5' - 10' GRAVELLY COARSE SAND

0-2.5' SANDY CLAY LOAM  
2.5' - 10' GRAVELLY SANDY LOAM

### Field Verification of Initial Screening:

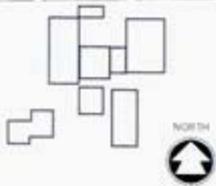
- Hydrologic Soil Groups (HSG)
  - ◆ On-site surface soil textures determine actual HSG
  - ◆ Actual HSG limits different than NRCS Soil Survey

0-3.0' SILTY CLAY LOAM  
3.0' - 5.0' SILTY CLAY

#### ACTUAL SOILS FOR SLAMM/TR-55:

-  SILT (HSG B)
-  CLAY (HSG C)
-  CLAY (HSG D)

TOWN ROAD



COUNTY HIGHWAY

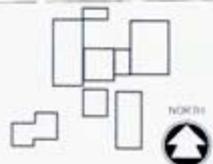
### Field Verification of Initial Screening:

- Depth to Seasonally High Groundwater

TOWN ROAD

#### DEPTH TO SEASONALLY HIGH GROUNDWATER:

- 0-1 FEET
- 1-3 FEET
- 3-5 FEET
- 5-7 FEET
- 7-9 FEET
- > 9 FEET



TOWN ROAD

0-1.5' LOAM  
 1.5' - 3' SANDY CLAY LOAM  
 3' - 4.5' GRAVELLY SANDY LOAM  
**4.5' - 10' GRAVELLY COARSE SAND**

GRAVELLY COARSE SAND IS NOT EXCLUDED IF BIORETENTION DEVICE IS USED, WHICH PROVIDES EQUIVALENT LEVEL OF PROTECTION (>20% FINES)

**0-2.5' SANDY CLAY LOAM**  
 2.5' - 10' GRAVELLY SANDY LOAM

SANDY CLAY AREA IS NOT EXEMPT IF BOTTOM OF INFILTRATION SYSTEM IS BELOW THE SANDY CLAY LOAM LAYER.

0-3.0' SILTY CLAY LOAM  
 3.0' - 5.0' SILTY CLAY

 POTENTIAL INFILTRATION EXEMPTION  
 POTENTIAL INFILTRATION EXCLUSION

USDA SOIL TEXTURE	NR 151.12(5)(c)6a INFILTRATION RATE*	NR 151.12(5)(c)5I PERCENT FINES*
GRAVELLY COARSE SAND		<20 %
GRAVELLY SANDY LOAM		>20 %
LOAM		>20 %
SANDY CLAY LOAM	< 0.6 in/hr	>20 %
SILTY CLAY LOAM	< 0.6 in/hr	>20 %
SILTY CLAY	< 0.6 in/hr	>20 %

\*Information from WDR Code 1002. No field measurements or laboratory tests conducted.

## Identifying Optimal Infiltration Areas:

- Infiltration Exclusions and Exemptions: Soils

# Identifying Optimal Infiltration Areas

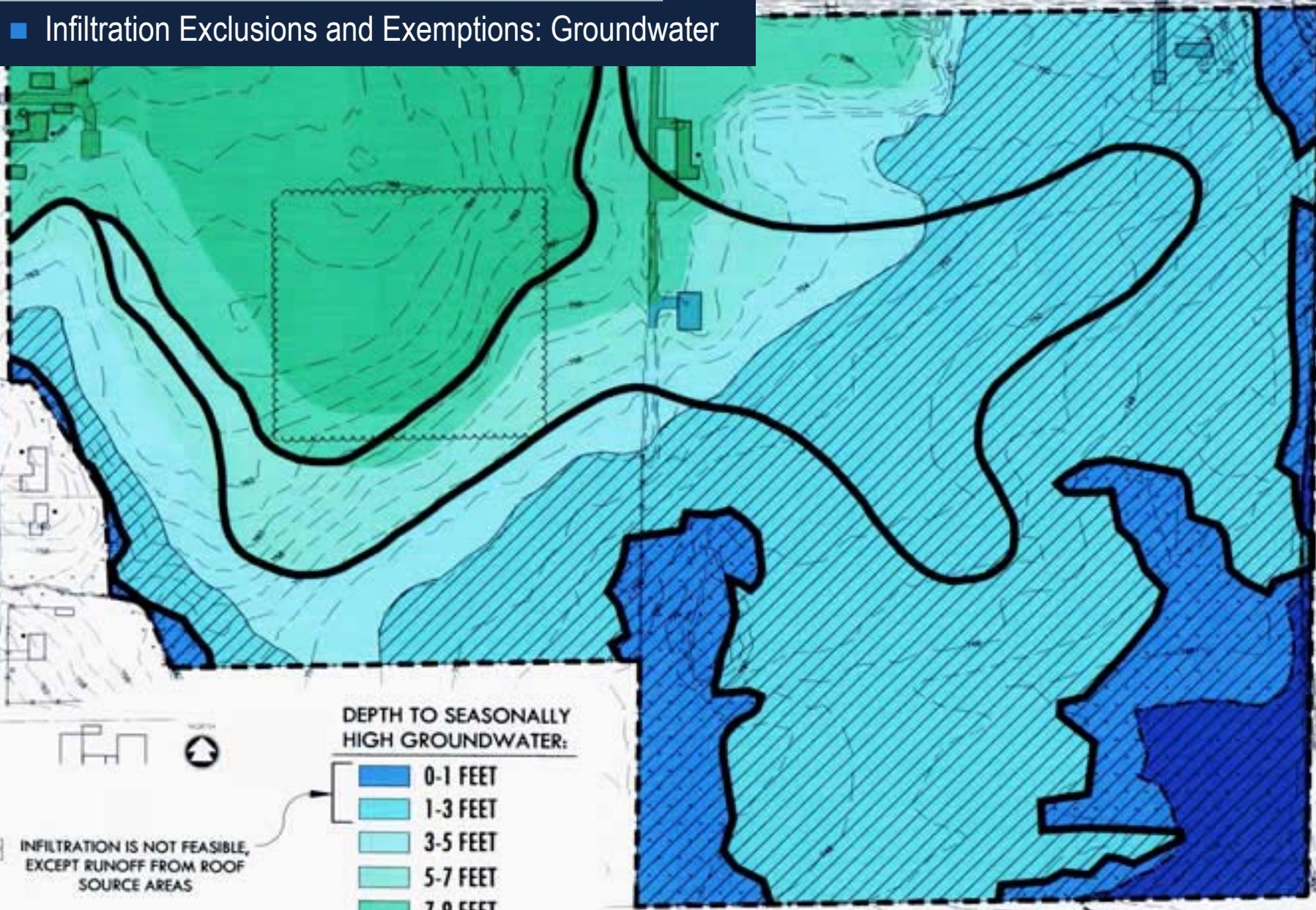
- Infiltration Exclusions and Exemptions:  
Groundwater
  - ◆ Residential areas with less than 3 feet from bottom of infiltration system to high groundwater. Infiltration of roof runoff is not prohibited.
  - ◆ Commercial areas with less than 5 feet from bottom of infiltration system to high groundwater.

# Identifying Optimal Infiltration Areas:

HIGHWAY

- Infiltration Exclusions and Exemptions: Groundwater

TOWN ROAD



DEPTH TO SEASONALLY HIGH GROUNDWATER:

- 0-1 FEET
- 1-3 FEET
- 3-5 FEET
- 5-7 FEET
- 7-9 FEET
- > 9 FEET

INfiltration IS NOT FEASIBLE, EXCEPT RUNOFF FROM ROOF SOURCE AREAS

TOWN ROAD

0-1.5' LOAM (L)  
 1.5' - 3' SANDY CLAY LOAM (SCL)  
 3' - 4.5' GRAVELLY SANDY LOAM (GSL)  
 4.5' - 10' GRAVELLY COARSE SAND (GCS)

0-2.5' SANDY CLAY LOAM (SCL)  
 2.5' - 10' GRAVELLY SANDY LOAM (GSL)

INFILTRATE  
 RUNOFF FROM  
 ROOFS ONLY

0-3.0' SILTY CLAY LOAM (SICL)  
 3.0' - 5.0' SILTY CLAY (SIC)

## Identifying Optimal Infiltration Areas:

- Design Infiltration Rates

DEPTH TO SEASONALLY HIGH GROUNDWATER:

- 0-1 FEET
- 1-3 FEET
- 3-5 FEET
- 5-7 FEET
- 7-9 FEET
- > 9 FEET

USDA SOIL TEXTURE	DESIGN INFILTRATION RATES (Inches/hr)*
GCS	3.60
GSL	0.50
L	0.24
SCL	0.11
SICL	0.04
SIC	0.07

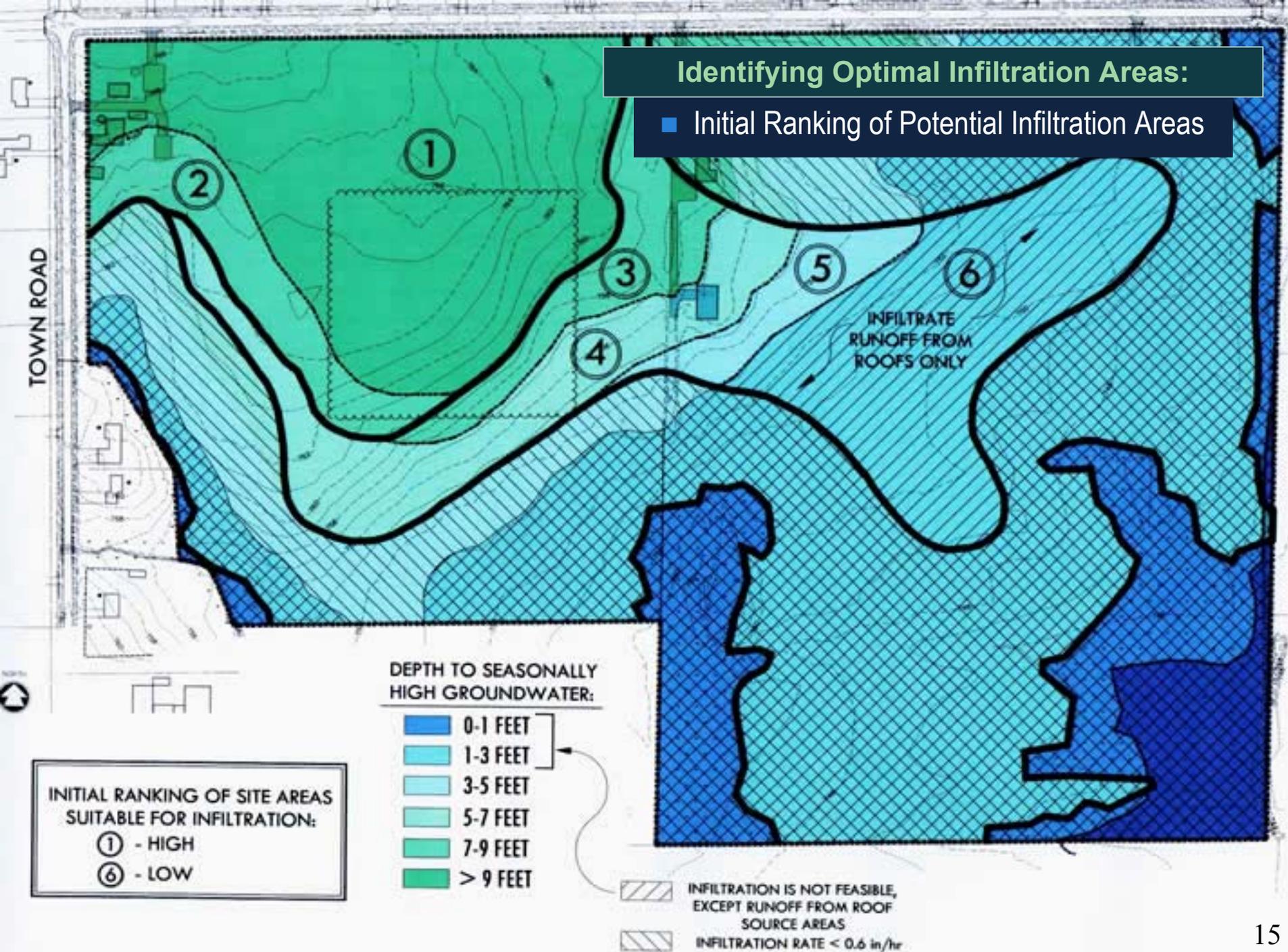
INFILTRATION IS NOT FEASIBLE, EXCEPT RUNOFF FROM ROOF SOURCE AREAS

INFILTRATION RATE < 0.6 in/hr

\*Infiltration rates from Table 2, WDNM Code 1002. No field measurements or laboratory tests conducted.

## Identifying Optimal Infiltration Areas:

- Initial Ranking of Potential Infiltration Areas



# Local Ordinances

- Total Suspended Solids:

- ◆ Same as NR 151.12(5)(a)

- Peak Discharge:

- ◆ New and redevelopment sites
- ◆ Reduce post-development peak flows to pre-development peak flows for 2, 10, and 100-year, 24-hour storms.
- ◆ Maximum pre-development curve number based on “meadow”

◆ Hydrologic Soil Group	A	B	C	D
◆ Runoff Curve Number	30	58	71	78

- Infiltration:

- ◆ Same as NR 151.12(5)(c)

- Protective Areas:

- ◆ Same as NR 151.12(5)(d)

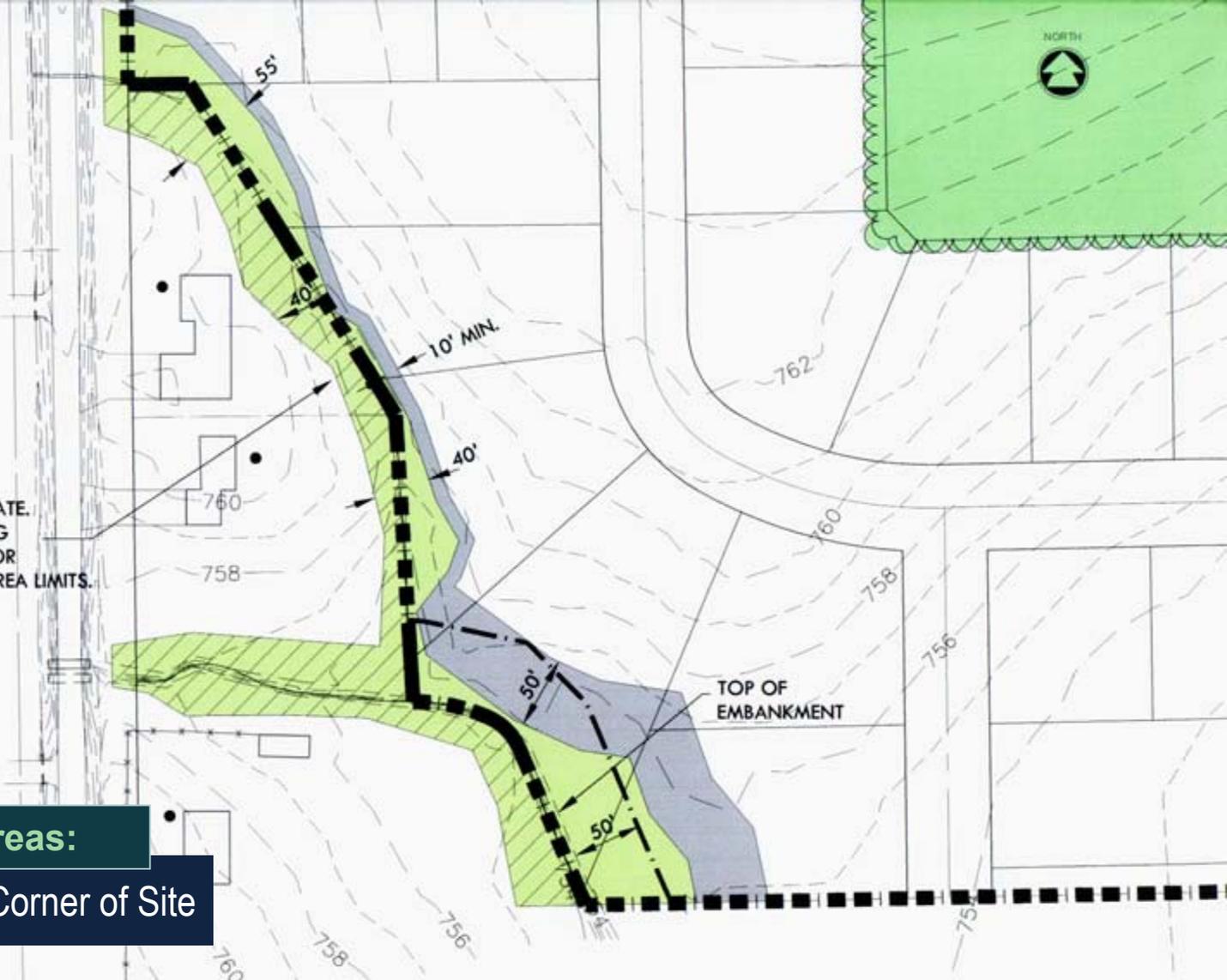
- Fueling and Vehicle Maintenance Areas:

- ◆ Same as NR 151.12(5)(e)

WETLAND BOUNDARY OFFSITE IS APPROXIMATE. BOUNDARY WAS GENERATED FROM EXISTING CONTOURS AND AERIAL PHOTOGRAPHY FOR PURPOSES OF DETERMINING PROTECTIVE AREA LIMITS.

### Protective Areas:

- Southwest Corner of Site



### PROTECTIVE AREA LIMITS:

STREAMS ON USGS TOPOGRAPHIC MAPS = 50 FEET  
DELINEATED WETLAND (LESS SUSCEPTIBLE)  
10% OF AVERAGE WETLAND WIDTH, BUT NO LESS  
THAN 10 FT OR GREATER THAN 30 FT  
DELINEATED WETLAND (HIGHLY SUSCEPTIBLE) = 50 FEET

## Protective Areas:

### PROTECTIVE AREA LIMITS:

- STREAMS ON USGS TOPOGRAPHIC MAPS = 50 FEET
- DELINEATED WETLAND (HIGHLY SUSCEPTIBLE) = 50 FEET
- DELINEATED WETLAND (LESS SUSCEPTIBLE) = 10-30 FEET

### LEGEND:

-  RE-DEVELOPMENT
-  PROTECTIVE AREA LIMITS



# Preliminary Development Plan:

**INFILTRATION:**  
INITIAL RANKING OF SITE AREAS  
SUITABLE FOR INFILTRATION:

- ① - HIGH
- ⑥ - LOW



**FILLING REQUIRED:**

- POOR SANITARY SEWER DEPTH
- CONDITIONS NOT IDEAL FOR INFILTRATION
- IMPROVE DRAINAGE
- DISPOSAL AREA FOR WET POND CONSTRUCTION

**WET PONDS:**

- SILTY CLAY SOIL
- LOW POINT OF SITE
- MAINTAIN WETLAND HYDROLOGY

# Final Development Plan

## ■ Modifications to Preliminary Development Plan:

- ◆ Conserve larger wooded area
- ◆ Preserve permeable soils
- ◆ Reduce imperviousness, particularly within permeable soils
- ◆ Disconnect residential roof drains (Compared to DNR standard land use files)
- ◆ Benefits of modifications include: Reduced runoff volume, peak flows, TSS load, and required infiltration volume

### Curve Number Comparison: Post vs. Pre-Development

TR-55 LAND USES	SOIL TYPE B		SOIL TYPE C		SOIL TYPE D	
	CN	DIFF	CN	DIFF	CN	DIFF
• Meadow	58		71		78	
• Park Open Space	61	5%	74	4%	80	2%
• Residential (1/4 ac)	75	29%	83	17%	87	12%
• Commercial	92	59%	94	32%	95	22%

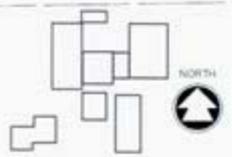
COUNTY HIGHWAY

TOWN ROAD

0-1.5' LOAM  
1.5' - 3' SANDY CLAY LOAM  
3' - 4.5' GRAVELLY SANDY LOAM  
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3.0' - 5.0' SILTY CLAY



**Final Development Plan:**

COUNTY HIGHWAY

TOWN ROAD

Limits of Land Disturbance:

LIMITS OF LAND DISTURBANCE

- LAND ACQUISITION = 87.90 AC.
- LAND DISTURBANCE = 75.50 AC.
- INCLUDE DISTURBED AREAS OUTSIDE PROPERTY LINES
- EXCLUDE NATURAL WETLANDS INSIDE PROPERTY LINES



# Infiltration

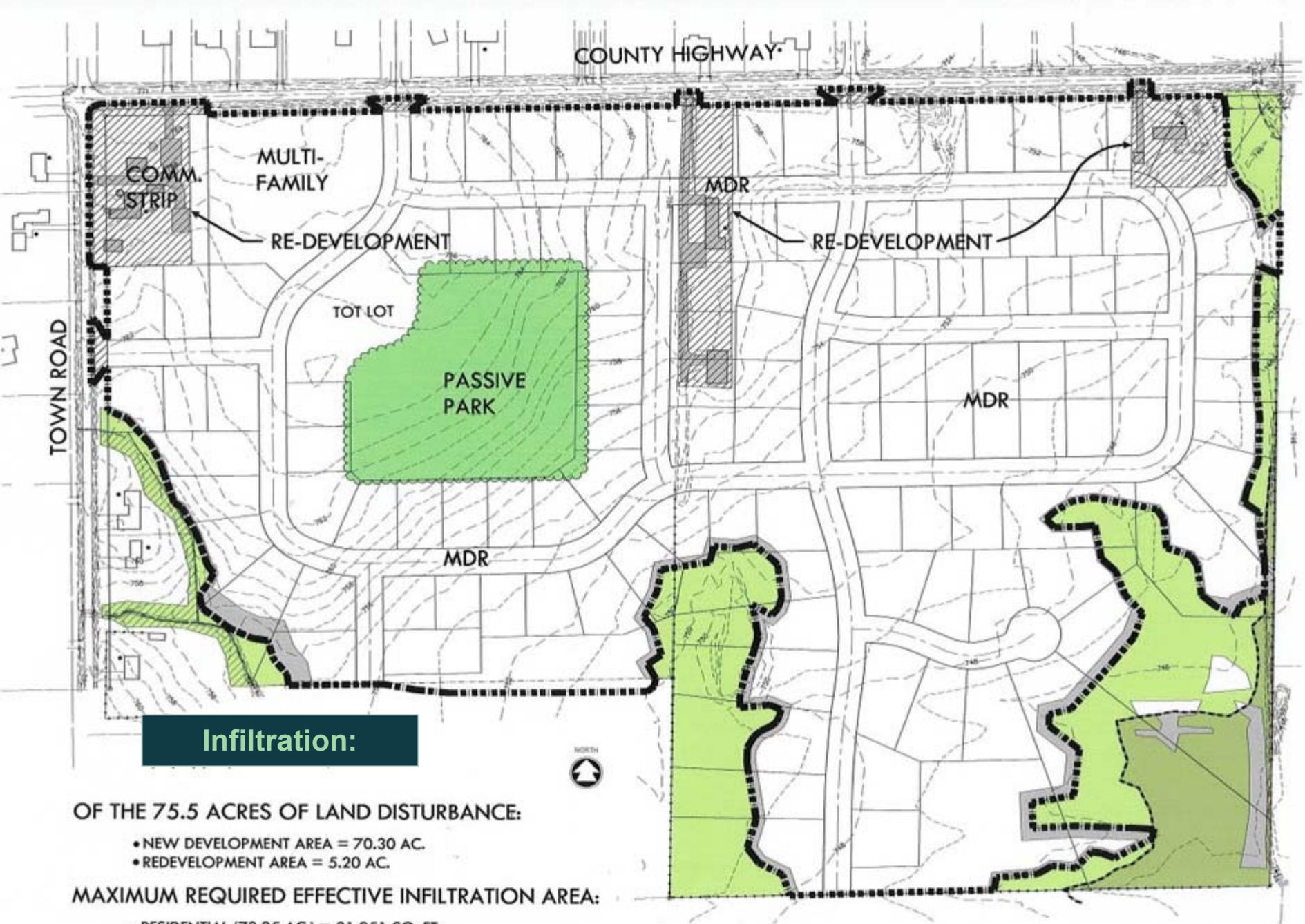
## ■ Residential Development

- ◆ Post-development infiltration volumes shall be at least 90% of pre-development infiltration volumes
- ◆ Max. 1 % of project site required for effective infiltration area

## ■ Non-Residential Development

- ◆ Post-development infiltration volumes shall be at least 60% of pre-development infiltration volumes
- ◆ Max. 2 % of project site required for effective infiltration area

## ■ Redevelopment areas are exempt from infiltration



**Infiltration:**

**OF THE 75.5 ACRES OF LAND DISTURBANCE:**

- NEW DEVELOPMENT AREA = 70.30 AC.
- REDEVELOPMENT AREA = 5.20 AC.

**MAXIMUM REQUIRED EFFECTIVE INFILTRATION AREA:**

- RESIDENTIAL (73.35 AC.) = 31,951 SQ. FT.
- NON-RESIDENTIAL (2.15 AC.) = 1,723 SQ. FT.
- TOTAL (75.50 AC.) = 33,674 SQ. FT. (CAP MAY BE VOLUNTARILY EXCEEDED)

# Infiltration

- SLAMM “Undeveloped” source area for pre-developed
- Pre-development SLAMM results are as follows:

NEW DEVELOPMENT AREAS ONLY	AREA (acres)	SLAMM SOIL TYPE	AVERAGE ANNUAL RAINFALL VOLUME (cu.ft.)	PRE-DEVELOPMENT	
				RUNOFF VOLUME (cu.ft.)	INFILTRATION VOLUME (cu.ft.)
• Non-Residential	0.20	Silt	16,429	543	15,886
• Residential	14.95	Silt	1,228,096	40,610	1,187,486
• Residential	55.15	Clay	4,530,402	213,542	4,316,860
Total	70.30		5,774,927	254,695	5,520,232

# Infiltration

- Determine minimum required post-development infiltration volume

NEW DEVELOPMENT AREAS ONLY	AREA (acres)	SLAMM SOIL TYPE	PRE-DEVELOP INFILTRATION VOLUME (cu.ft.)	NR 151 INFILTRATION REQUIRED	MINIMUM REQUIRED POST-DEVELOP INFILTRATION VOLUME (cu.ft.)
• Non-Residential	0.20	Silt	15,886	60%	9,532
• Residential	14.95	Silt	1,187,486	90%	1,068,737
• Residential	55.15	Clay	4,316,860	90%	3,885,174
Total	70.30		5,520,232		4,963,443

# Infiltration

- Post-development SLAMM results are as follows:

NEW DEVELOPMENT AREAS ONLY	AREA (acres)	SLAMM SOIL TYPE	AVERAGE ANNUAL RAINFALL VOLUME (cu.ft.)	POST-DEVELOPMENT	
				RUNOFF VOLUME (cu.ft.)	INFILTRATION VOLUME (cu.ft.)
• Non-Residential	0.20	Silt	16,429	10,448	5,941
• Residential	14.95	Silt	1,228,096	167,205	1,060,891
• Residential	55.15	Clay	4,530,402	827,468	3,702,934
Total	70.30		5,774,927	1,005,161	4,769,766

# Infiltration

- Determine required post-development runoff volume to be infiltrated:

NEW DEVELOPMENT AREAS ONLY	AREA (acres)	SLAMM SOIL TYPE	MINIMUM REQUIRED (cu.ft.)	POST-DEVELOPMENT INFILTRATION VOLUME	
				PROVIDED No BMP's (cu.ft.)	REQUIRED FOR BMP's (cu.ft.)
• Non-Residential	0.20	Silt	9,532	5,941	3,591
• Residential	14.95	Silt	1,068,737	1,060,891	7,846
• Residential	55.15	Clay	3,885,174	3,702,934	182,240
Total	70.30		4,963,443	4,769,766	193,677

# Infiltration

## ■ Preliminary evaluation of infiltration requirement

- ◆ Runoff volume from silt soils is 177,693 cu.ft.
- ◆ Infiltrate 15,984 cu.ft. or more runoff volume from clay soils to satisfy the 193,677 cu.ft. infiltration requirement
- ◆ Clay soil designation only represents the uppermost soil texture

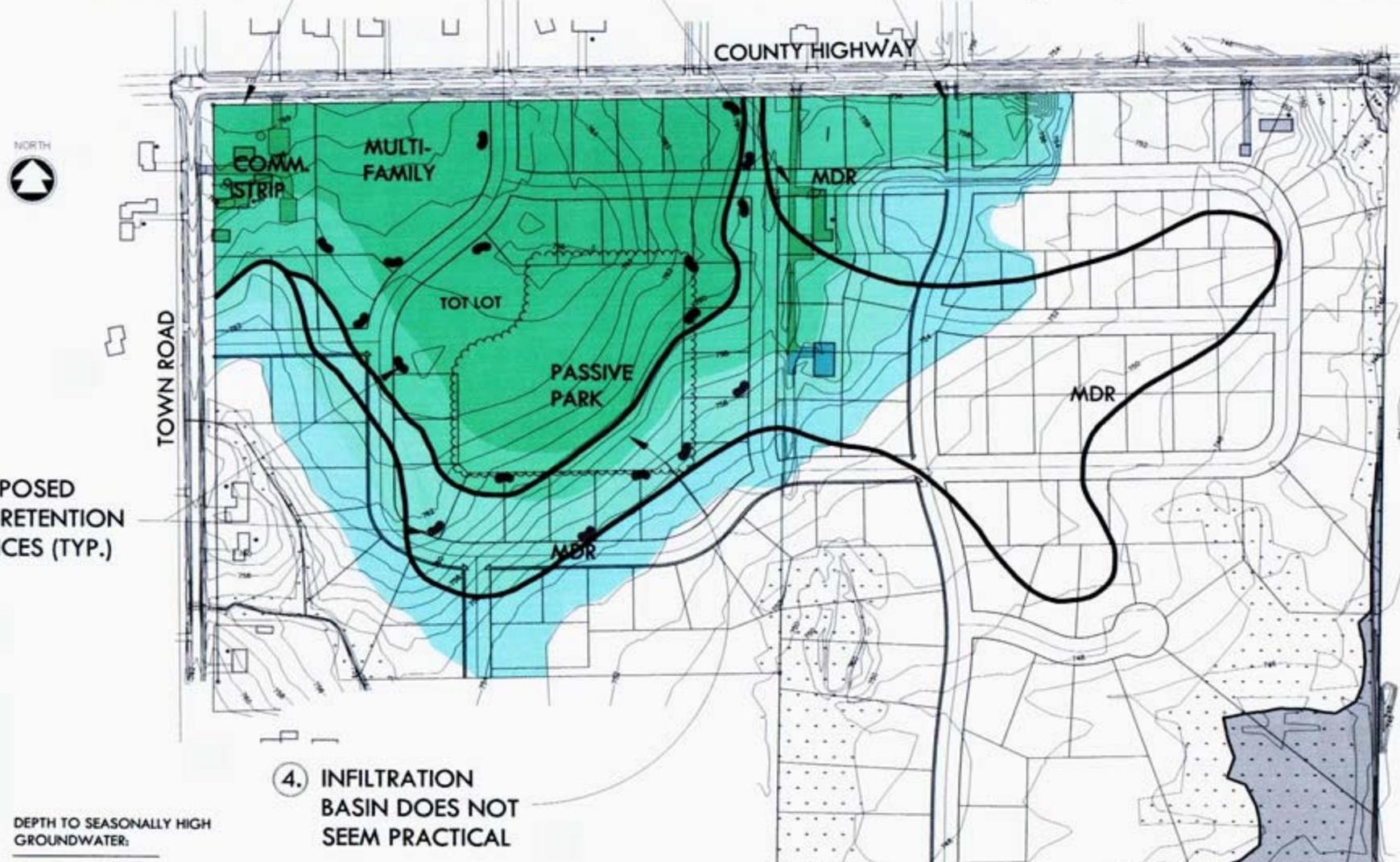
NEW DEVELOPMENT AREAS ONLY	AREA (acres)	SLAMM SOIL TYPE	RUNOFF VOLUME (cu.ft.)	POST-DEVELOPMENT BMP INFILTRATION VOLUME REQUIRED (cu.ft.)
• Non-Residential	0.20	Silt	10,488	3,591
• Residential	14.95	Silt	167,205	7,846
• Residential	55.15	Clay	827,468	182,240
Total	70.30		1,005,161	193,677

# Infiltration

## ■ Infiltration Considerations:

- ◆ Infiltration Grass Swales (Code 1005):
  - ◆ Highest permeable soil is not at ground surface
  - ◆ Developer dislikes rural streets with culverts
  - ◆ Rural streets may have sidewalk challenges
- ◆ Infiltration Basin (Code 1003):
  - ◆ Residential pretreatment: 60% TSS removal
  - ◆ Highest permeable soil is not at ground surface
  - ◆ Groundwater mounding considerations
- ◆ Bioretention (Code 1004):
  - ◆ Engineered soil (3 ft) replaces low permeable soils
  - ◆ Bioretention device fits within a residential lot
  - ◆ Provides equivalent protection if < 20% fines

- 1. POTENTIAL GAS STATION SITE
- 2. RE-DEVELOPMENT (SOIL COMPACTION)
- 3. PROPOSED SIDEWALK TO TOT LOT/PARK (GRASS SWALE CONFLICT)



- 5. PROPOSED BIO-RETENTION DEVICES (TYP.)

- 4. INFILTRATION BASIN DOES NOT SEEM PRACTICAL

DEPTH TO SEASONALLY HIGH GROUNDWATER:

	3-5 FEET
	5-7 FEET
	7-9 FEET
	> 9 FEET



MOUNTABLE CURB AND GUTTER

**Infiltration:**

- Infiltration Considerations

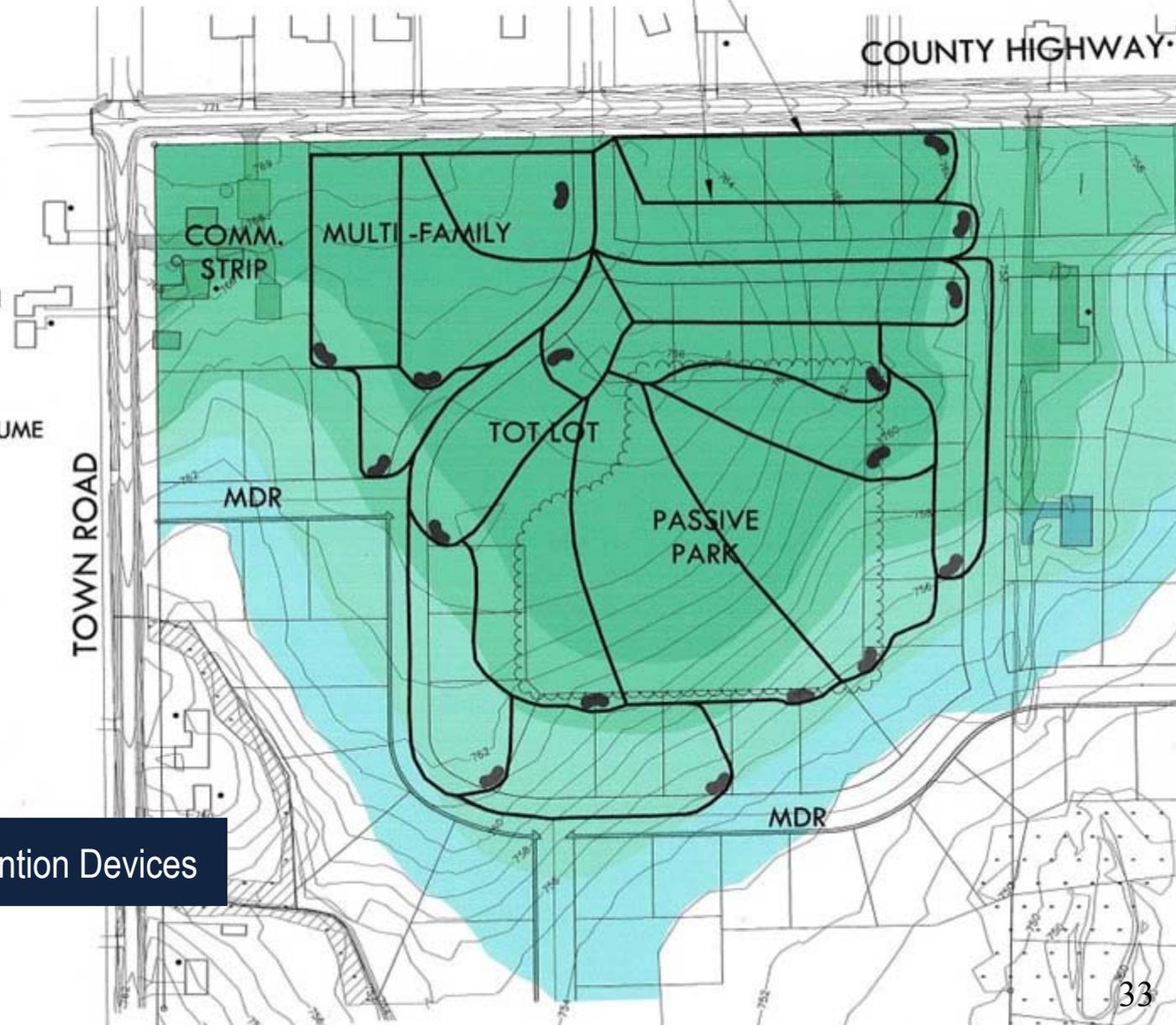
BIO-RETENTION DRAINAGE AREA BOUNDARY



COUNTY HIGHWAY

PROPOSED BIO-RETENTION DEVICES:

- BIO-RETENTION DEVICES = 17
- AVERAGE DRAINAGE AREA/ DEVICE = 1.1 AC.
- AVERAGE EFFECTIVE INFILTRATION AREA = 9FT. x 18 FT.
- TOTAL EFFECTIVE INFILTRATION AREA PROVIDED = 2,754 SQ. FT.
- MAXIMUM EFFECTIVE INFILTRATION AREA REQUIRED = 33,674 SQ FT.
- MIN. INFILTRATION VOLUME REQUIRED = 193,677 CU. FT.
- BIO-RETENTION INFILTRATION VOLUME PROVIDED = 206,991 CU. FT.

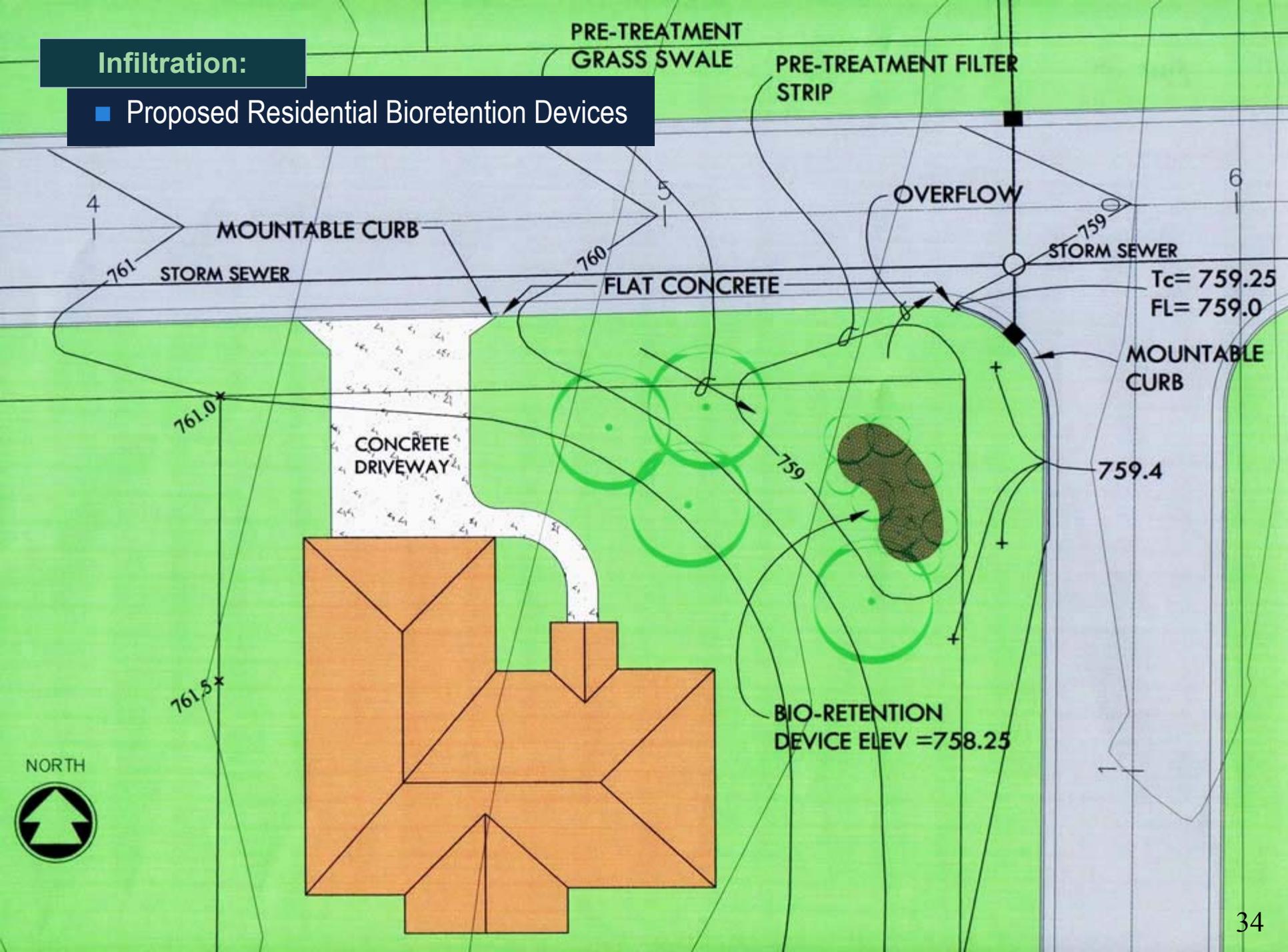


**Infiltration:**

- Proposed Bioretention Devices

# Infiltration:

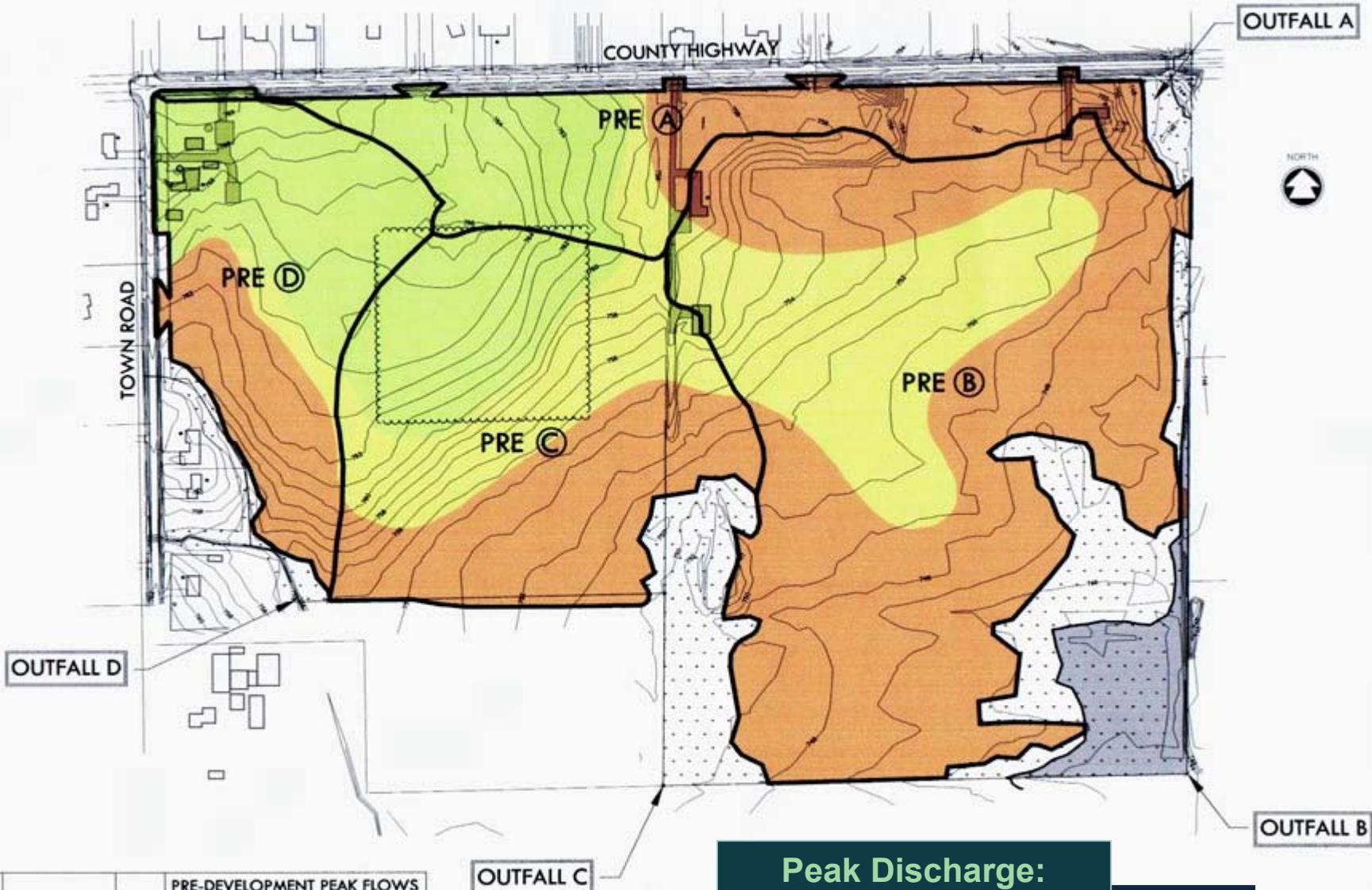
## ■ Proposed Residential Bioretention Devices



# Peak Discharge

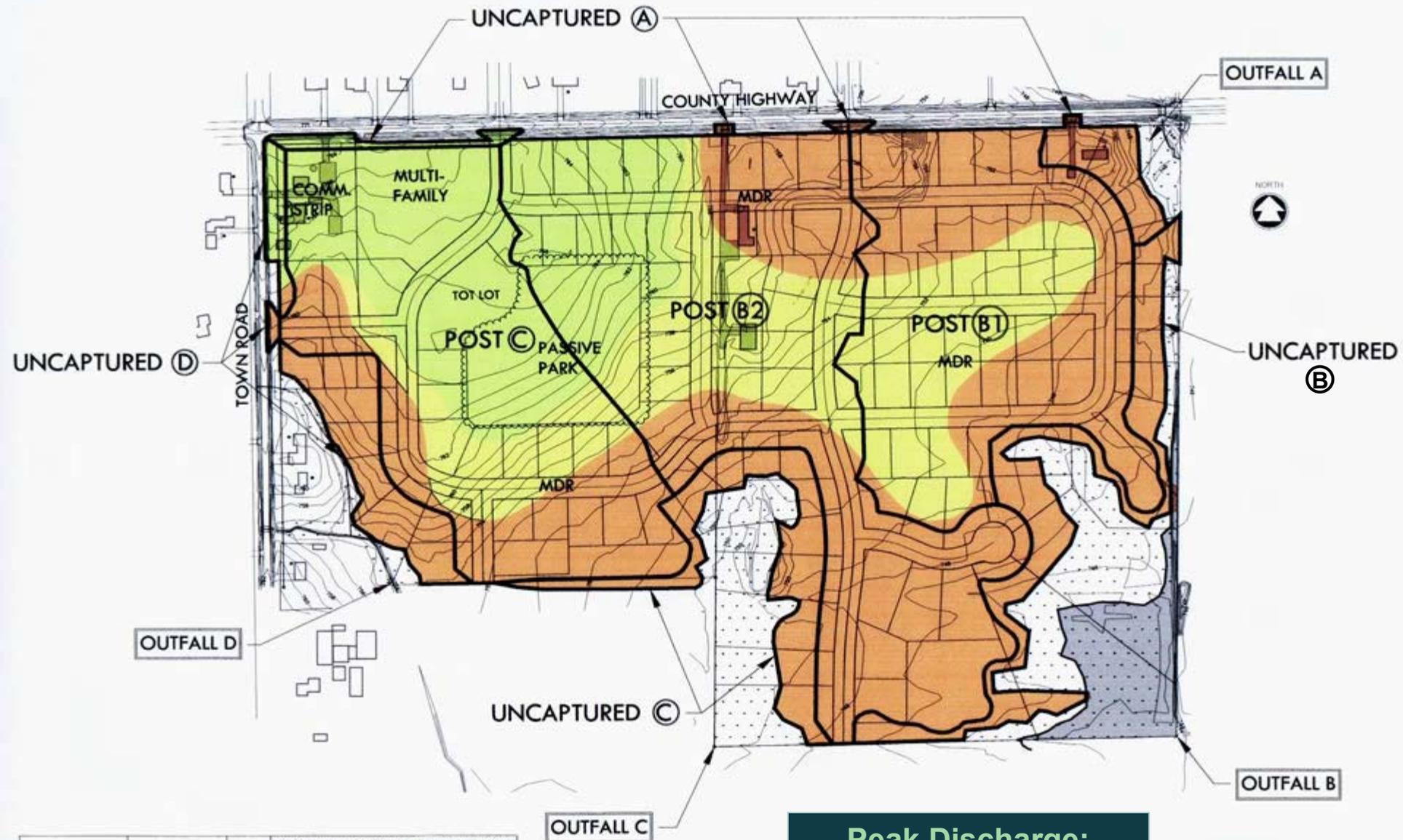
- Local Ordinance more restrictive than NR 151:
  - ◆ New and redeveloped sites
  - ◆ Reduce post-development peak flows to pre-development peak flows for the 2, 10, and 100-year, 24-hour storms
  - ◆ Maximum pre-development curve number based on “meadow”
 

◆ Hydrologic Soil Group	A	B	C	D
◆ Runoff Curve Number	30	58	71	78



**Peak Discharge:**  
 ■ Predevelopment Peak Flows

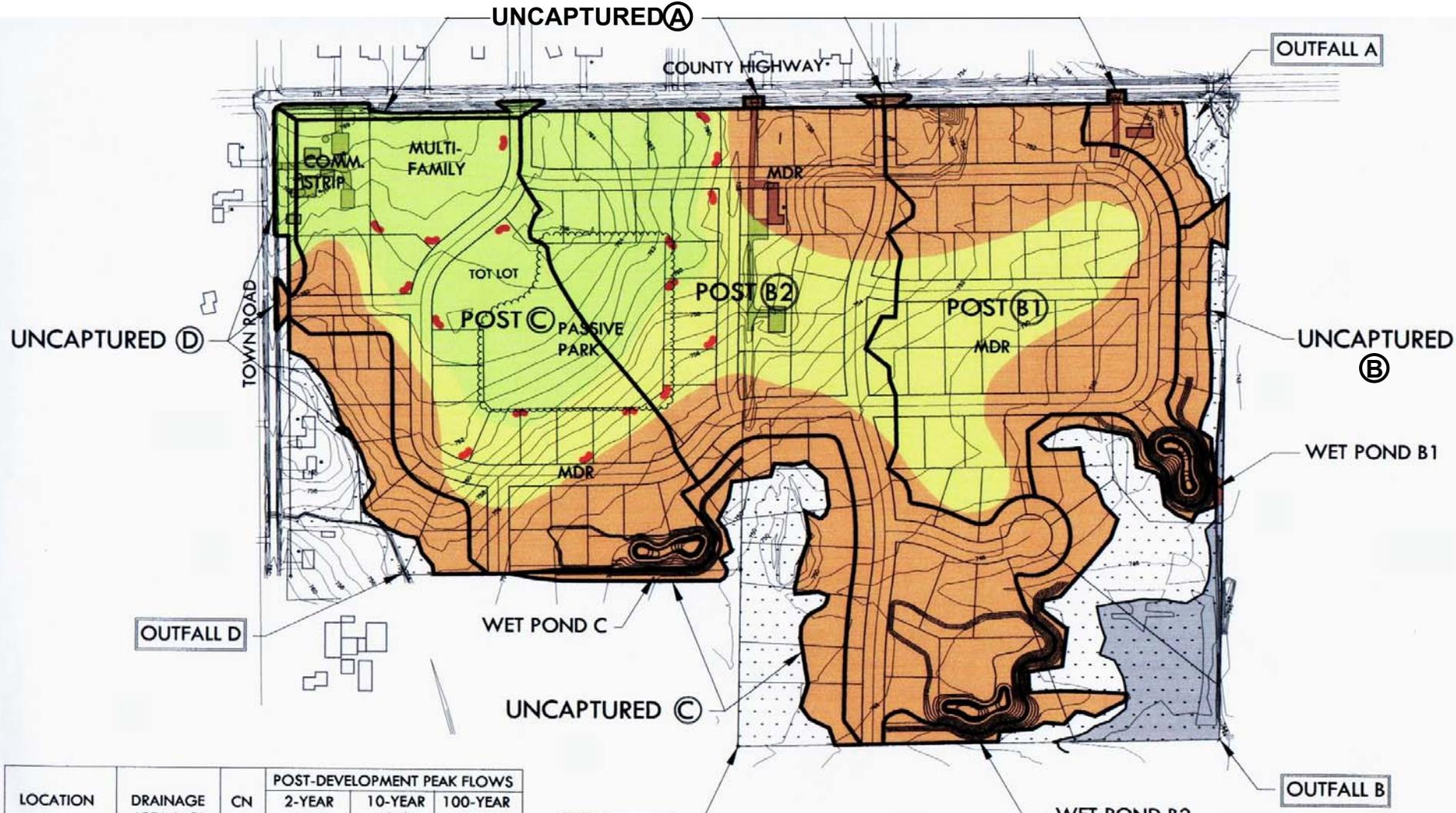
LOCATION	DRAINAGE AREA (AC.)	CN	PRE-DEVELOPMENT PEAK FLOWS		
			2-YEAR (CFS)	10-YEAR (CFS)	100-YEAR (CFS)
OUTFALL A	10.10	67	2.13	7.58	16.38
OUTFALL B	35.20	76	9.20	29.92	63.53
OUTFALL C	18.50	70	4.60	13.92	28.17
OUTFALL D	11.70	66	2.29	8.69	19.20
TOTAL	75.50	72			



LOCATION	DRAINAGE AREA (AC.)	CN	POST-DEVELOPMENT PEAK FLOWS		
			2-YEAR (CFS)	10-YEAR (CFS)	100-YEAR (CFS)
OUTFALL A	1.80	84	2.03	3.93	6.38
OUTFALL B	48.35	84	42.42	82.45	134.26
OUTFALL C	22.45	81	11.71	24.35	41.18
OUTFALL D	2.90	85	2.21	4.53	7.87
TOTAL:	75.50	83			

**Peak Discharge:**

- Post-development peak flows without any detention

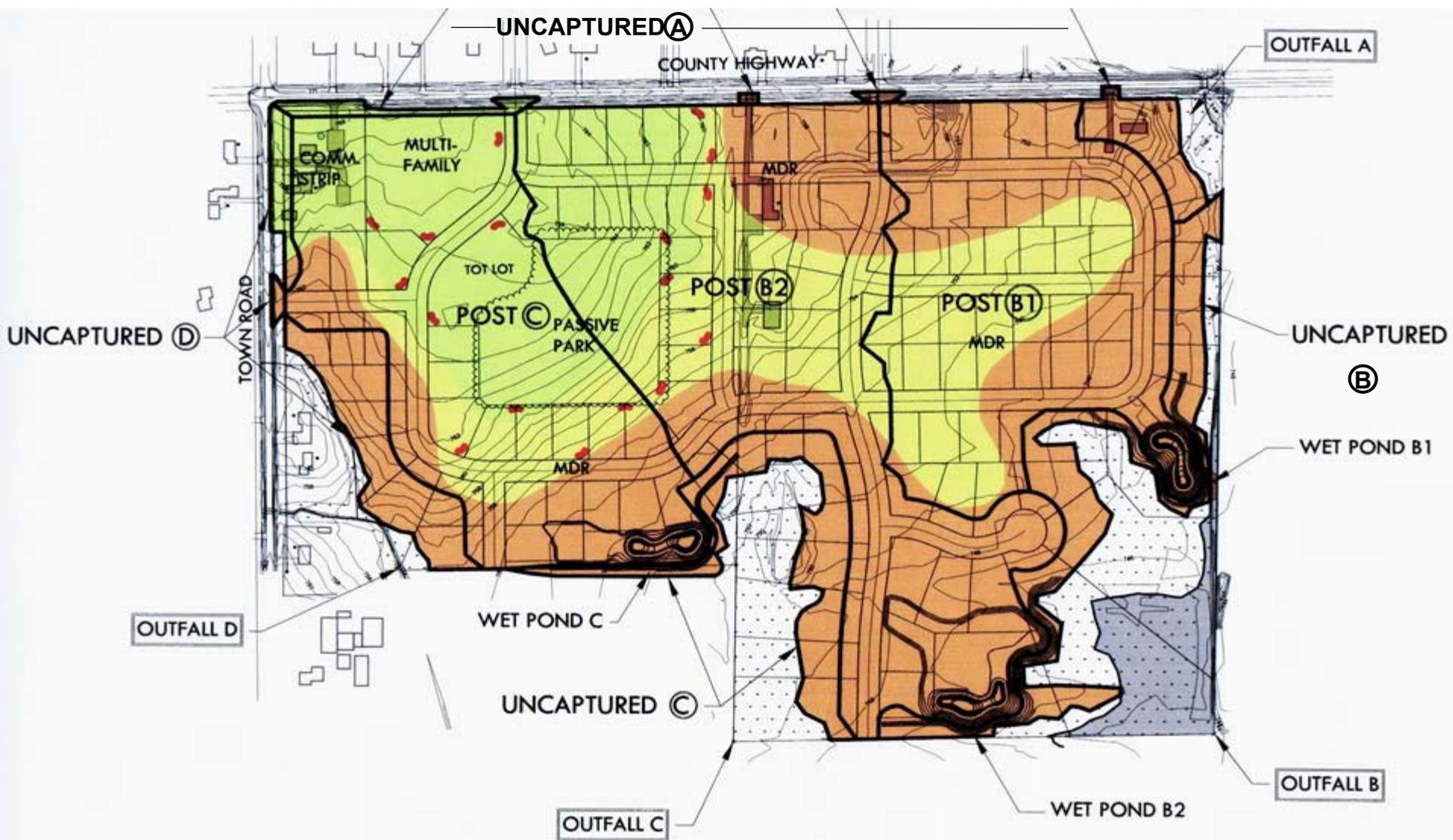


LOCATION	DRAINAGE AREA (AC.)	CN	POST-DEVELOPMENT PEAK FLOWS		
			2-YEAR (CFS)	10-YEAR (CFS)	100-YEAR (CFS)
OUTFALL A					
UNCAPTURED A	1.80	84	2.03	3.93	6.38
OUTFALL B					
WET POND B1	17.50	86	2.13	6.38	9.12
WET POND B2	26.65	83	2.61	20.14	41.16
UNCAPTURED B	4.20	83	4.01	7.94	13.06
SUBTOTAL:	48.35	84	5.65	26.93	55.10
OUTFALL C					
WET POND C	19.50	81	1.39	9.72	20.90
UNCAPTURED C	2.95	84	1.51	2.95	4.82
SUBTOTAL:	22.45	81	1.86	10.54	22.15
OUTFALL D					
UNCAPTURED D	2.90	85	2.21	4.53	7.87
TOTAL:	75.50	83			

TIME OF EACH PEAK FLOW IS CONSIDERED WHEN ADDING TOGETHER AT OUTFALL.

### Peak Discharge:

■ Post-development peak flows with wet ponds and bioretention



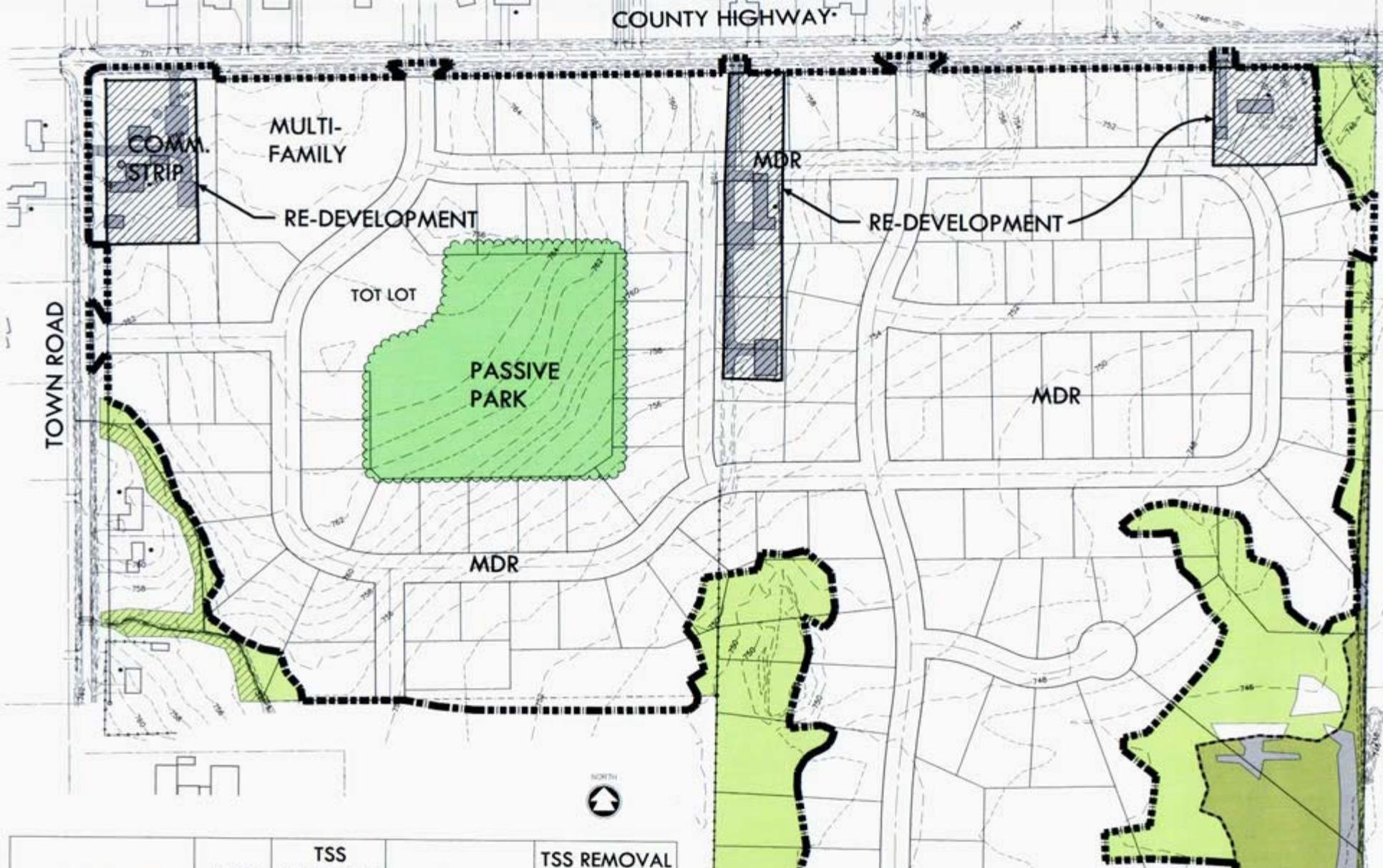
LOCATION	PRE-DEVELOPMENT PEAK FLOWS			POST-DEVELOPMENT PEAK FLOWS		
	2-YEAR (CFS)	10-YEAR (CFS)	100-YEAR (CFS)	2-YEAR (CFS)	10-YEAR (CFS)	100-YEAR (CFS)
OUTFALL A	2.13	7.58	16.38	2.03	3.93	6.38
OUTFALL B	9.20	29.92	63.53	5.65	26.93	55.10
OUTFALL C	4.60	13.92	28.17	1.86	10.54	22.15
OUTFALL D	2.29	8.69	19.20	2.21	4.53	7.87
TOTAL						

### Peak Discharge:

- Comparison of pre-development and post-development peak flows

# Total Suspended Solids (TSS)

- **New Development:** Reduce TSS load by 80% minimum as compared to no runoff management / BMP controls.
- **Redevelopment:** Reduce TSS load by 40% minimum as compared to no runoff management / BMP controls.



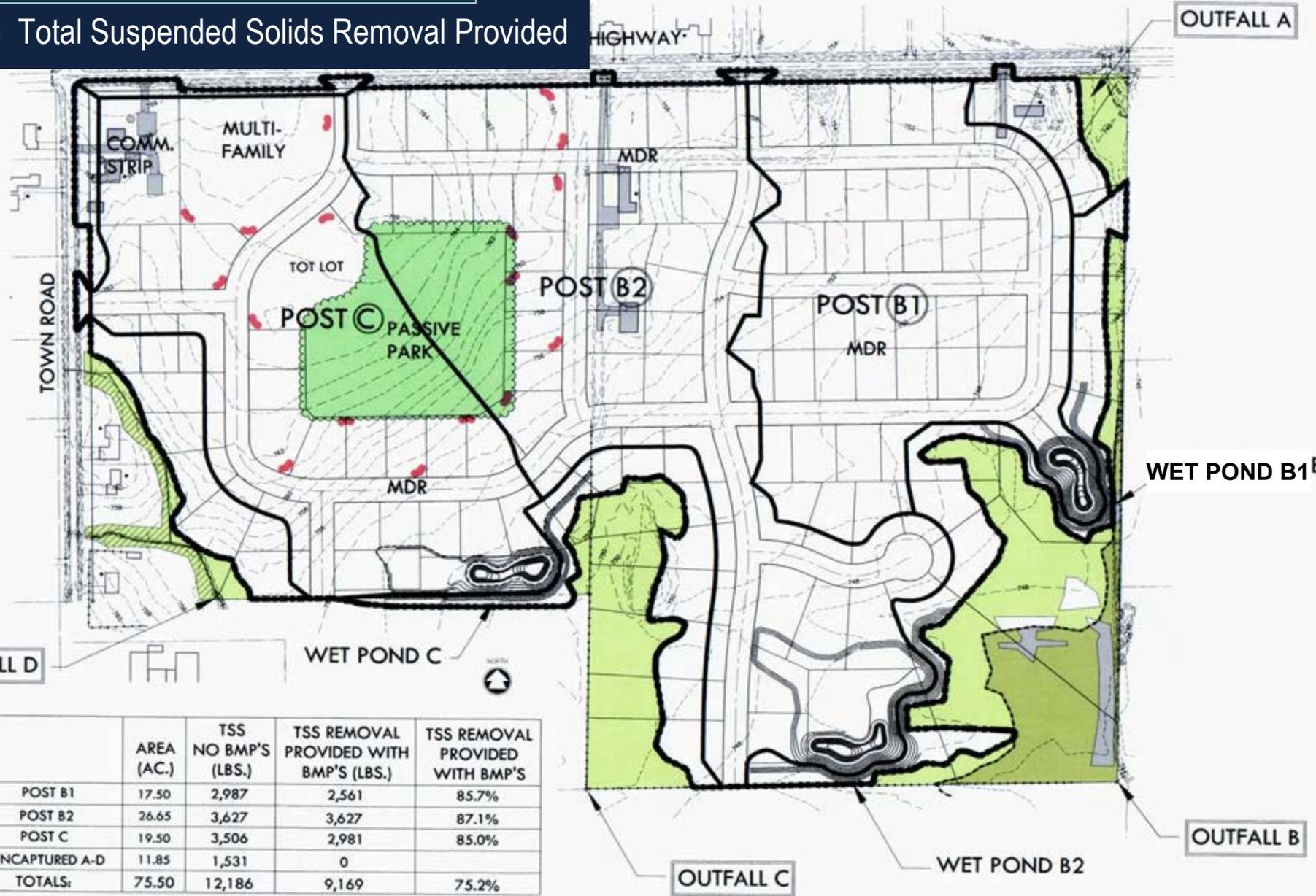
LOCATION	AREA (AC.)	TSS NO BMP'S (LBS.)	NR 151 REQUIREMENT	TSS REMOVAL REQUIRED (LBS.)
NEW DEVELOPMENT	70.30	10,382	80%	8,306
RE-DEVELOPMENT	5.20	1,804	40%	722
<b>TOTALS:</b>	<b>75.50</b>	<b>12,186</b>	<b>74.1%</b>	<b>9,028</b>

**Total Suspended Solids (TSS):**

- Total Suspended Solids Removal Required

# Total Suspended Solids (TSS):

## Total Suspended Solids Removal Provided



	AREA (AC.)	TSS NO BMP'S (LBS.)	TSS REMOVAL PROVIDED WITH BMP'S (LBS.)	TSS REMOVAL PROVIDED WITH BMP'S (%)
POST B1	17.50	2,987	2,561	85.7%
POST B2	26.65	3,627	3,627	87.1%
POST C	19.50	3,506	2,981	85.0%
UNCAPTURED A-D	11.85	1,531	0	
<b>TOTALS:</b>	<b>75.50</b>	<b>12,186</b>	<b>9,169</b>	<b>75.2%</b>

• TSS REMOVAL REQUIRED = 9,028 LBS. OR 74.1%