Phillips Drive Neighborhood
Water Drainage Issues
Report to Mayor Donna Holaday, June 2017

- CITY RESPONSE AND UPDATE -
PUBLIC MEETING
Senior Center
SEPTEMBER 27, 2017

Department of Public Services
Engineering Division
16C Perry Way
Newburyport, MA 01950

What We've Done So Far

- Reviewed Resident's June 2017 Comments to Mayor Holaday
- Reviewed historical data – files, letters, plans, soil data, grant applications
- CCTV Inspections of drainage piping
- Field survey to obtain latest existing conditions of drainage system

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What We’ve Done So Far

- Began hydrologic & hydraulic modeling of the Phillips Drive Neighborhood and Cherry Hill Development
- Reviewed Drainage Report and design Plans of the Cherry Hill Development
- Held many discussions with residents, contractors, and city staff

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Primary Issues:

1. Groundwater
2. Surface flooding
3. Roadway Construction

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Simplified Definitions:

Hydrology –

The science of water and its characteristics on the surface. First we quantify how much rainfall hits the earth, then how much evaporates, then how much infiltrates, then how much *runs off* downhill. Once enough is collected in a definitive shaped conveyance (stream, ditch, swale, pipe) then the science switches to hydraulics.

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Simplified Definitions:

Hydraulics –

The physics of flow in a conveyance structure, such as, closed underground drainage pipe or in an open channel, swale or ditch at the surface. We look at the shape and type of conveyance in order to calculate the hydraulic characteristics.

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Simplified Definitions:

Groundwater –

Water underground. Groundwater will move within the voids of soil and rock, from a higher elevation to a lower elevation. The tighter the soil (fine clays, fine silts) the slower the movement. The looser more granular the soil (gravels, sands) the faster the movement.

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Simplified Definitions:

Groundwater (continued) –

Groundwater commonly flows thru permeable soils that sit above a soil layer that's nearly impermeable, like clays and ledge. This is typically called a 'perched groundwater condition'.

Phillips Drive Neighborhood has a perched groundwater condition.

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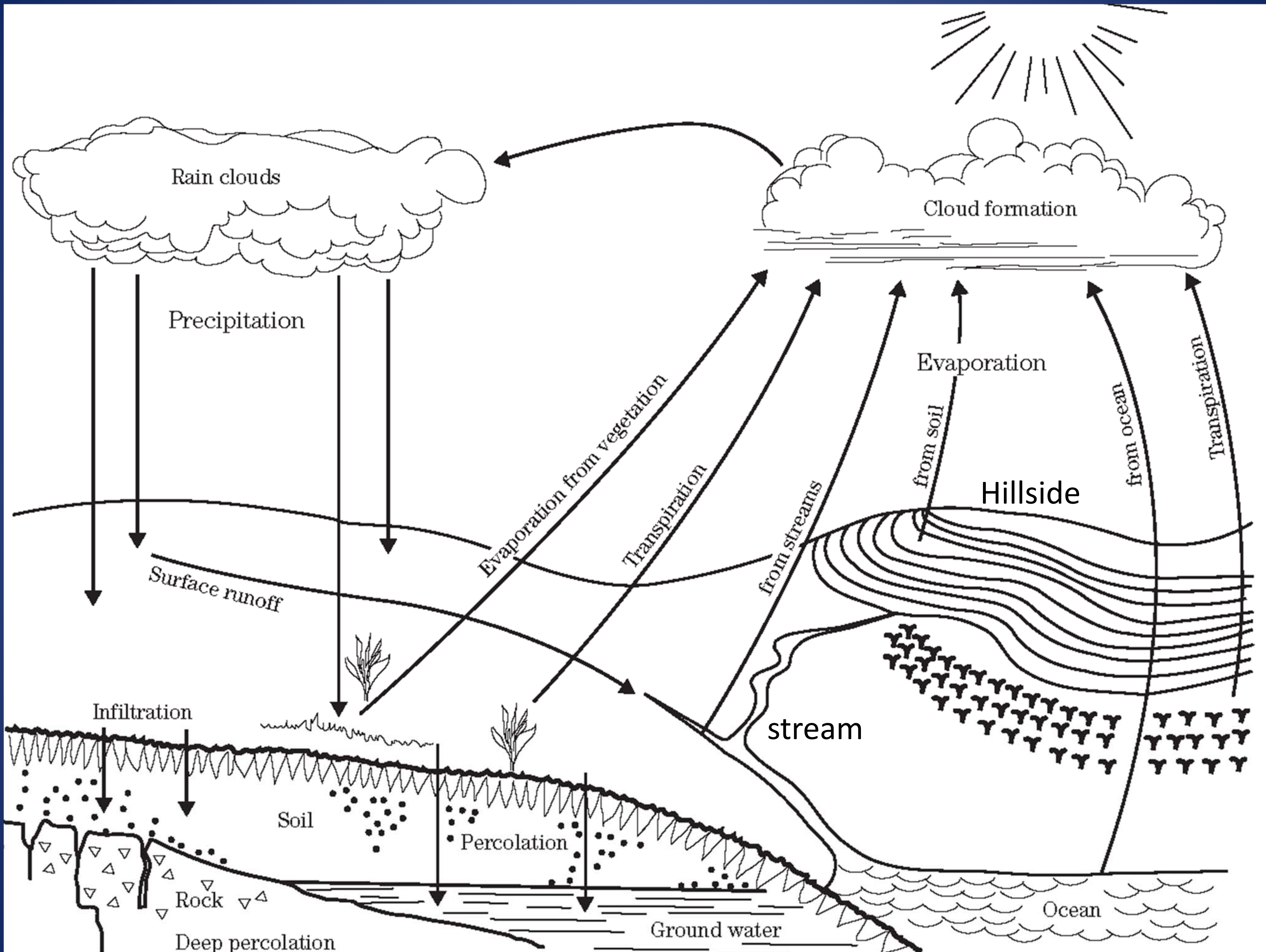
Rain clouds
Cloud formation
Precipitation
Evaporation from vegetation
Transpiration
from streams
Evaporation
from soil
from ocean
Transpiration
Hillside
Surface runoff
stream
Infiltration
Soil
Percolation
Rock
Deep percolation
Ground water
Ocean

Simplified Definitions:

Groundwater Drainage –

This term is commonly misused. A true groundwater drainage *system* is a subdrain, perimeter drain, French-drain, etc. It's a perforated pipe installed underground into the groundwater with the goal of intercepting the groundwater and transporting it elsewhere, thereby lowering the groundwater at that location.

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Simplified Definitions:

Pipe Trench –

The 3-dimensional area created when an underground pipe is installed:

- Typically 4’ Wide x 6’ Deep x Pipe Length
- Excavate to depth the pipe needs to be
- Install bedding soil along the bottom of the trench for the pipe to sit on
- Install pipe then backfill with soil

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Simplified Definitions:

Pipe Trench (continued) –

Most of the time the backfill soil is the same soil that was excavated out to install the pipe but sometimes it's imported material that is of a better material (i.e. more gravelly, sandy, etc.).

Therefore, groundwater can travel within pipe trenches if the trench soils are more permeable than the adjacent soils.

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Typical Pipe Trenches

Simplified Definitions:

Roadway Drainage –

- Combines hydrology with hydraulics
- Generally 2-types of roadway drainage systems:
  - *Country drainage* – no curbs, stormwater *runs off* the road into swales, ditches, channels.
  - *Closed drainage system* – a series of catch basins collect the roadway *runoff* and transport it in underground (closed) pipes. Eventually outletting into streams, wetlands, etc.

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Simplified Definitions:

Roadway Drainage (continued) –

- Closed drainage systems are typically designed to handle a 10-year storm event
- Phillips Drive Neighborhood has a *hybrid* drainage system – country and closed
  - no curb
  - some catch basins
  - piping to streams
  - surface runoff to streams

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END OF DEFINITIONS

HYDROLOGIC SOIL GROUPS

GROUP A:	Low runoff potential, high infiltration 90%+ Sands and Gravels
Group B:	Moderately low runoff, good infiltration 50% - 90% Sand Loamy sand or sandy loam texture
Group C:	Moderately high runoff, restricted infiltration < 50% sand, 20%-40% clay Silty loam, sandy clay
Group D:	High runoff, low infiltration potential >40% clay, <50% sand Clays, silts

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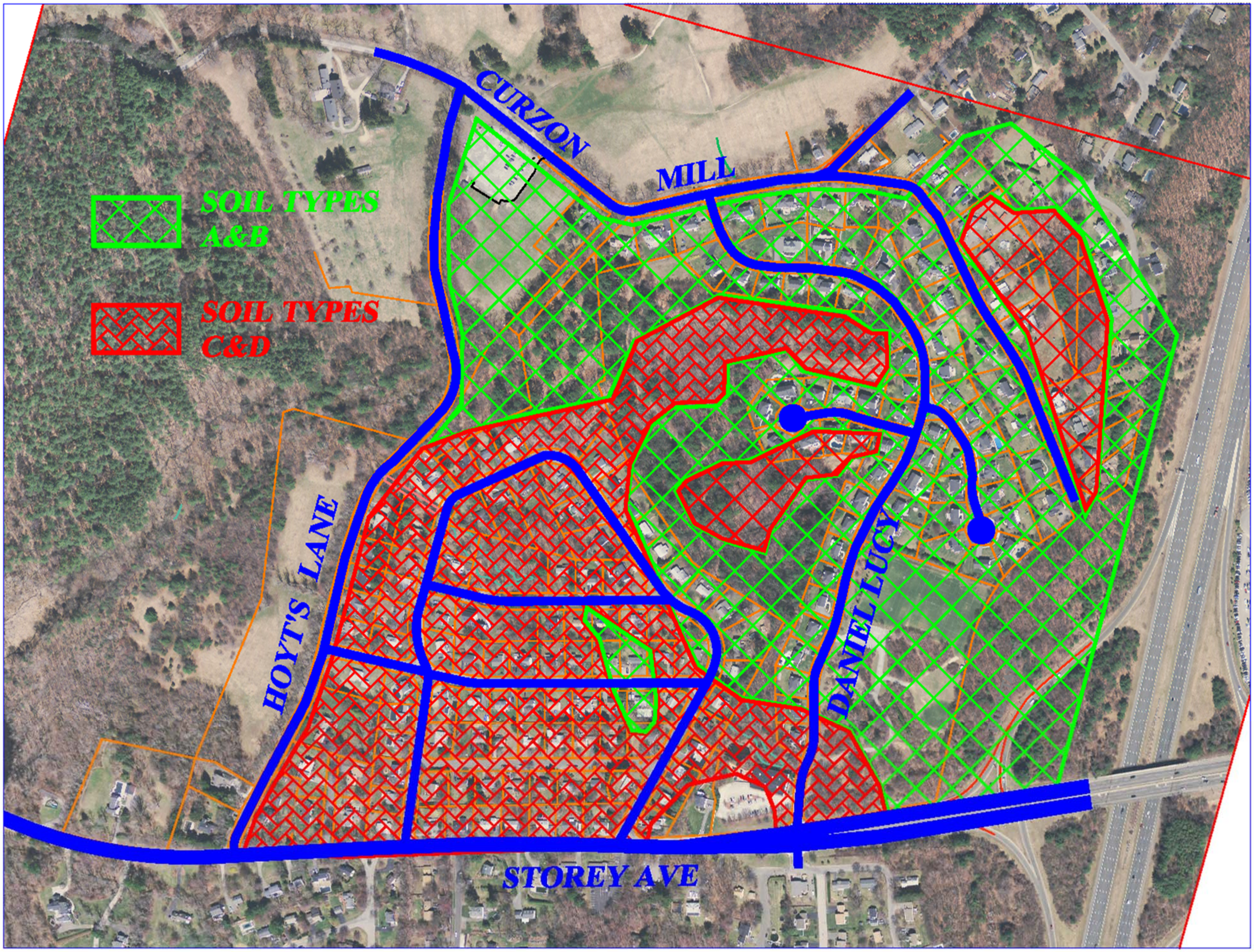

CURZON
MILL
SOIL TYPES A&B
SOIL TYPES C&D
HOYT'S LANE
DANIEL LUCY
STOREY AVE

Phillips Drive Neighborhood Existing Soils

- Prior to development, Phillips Drive was a wetland. Tight, generally impervious soils – Soil Groups C and D
- High (perched) groundwater
- Pre-existing groundwater problems

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Cherry Hill Development

Pre-Development conditions:

- Tree farm – Rhododendrons (small plants)
- Combination of well-draining soils and impermeable soils
- Primarily had 3 storm water runoff discharge locations
- Developer estimated pre-development runoff rates and volumes

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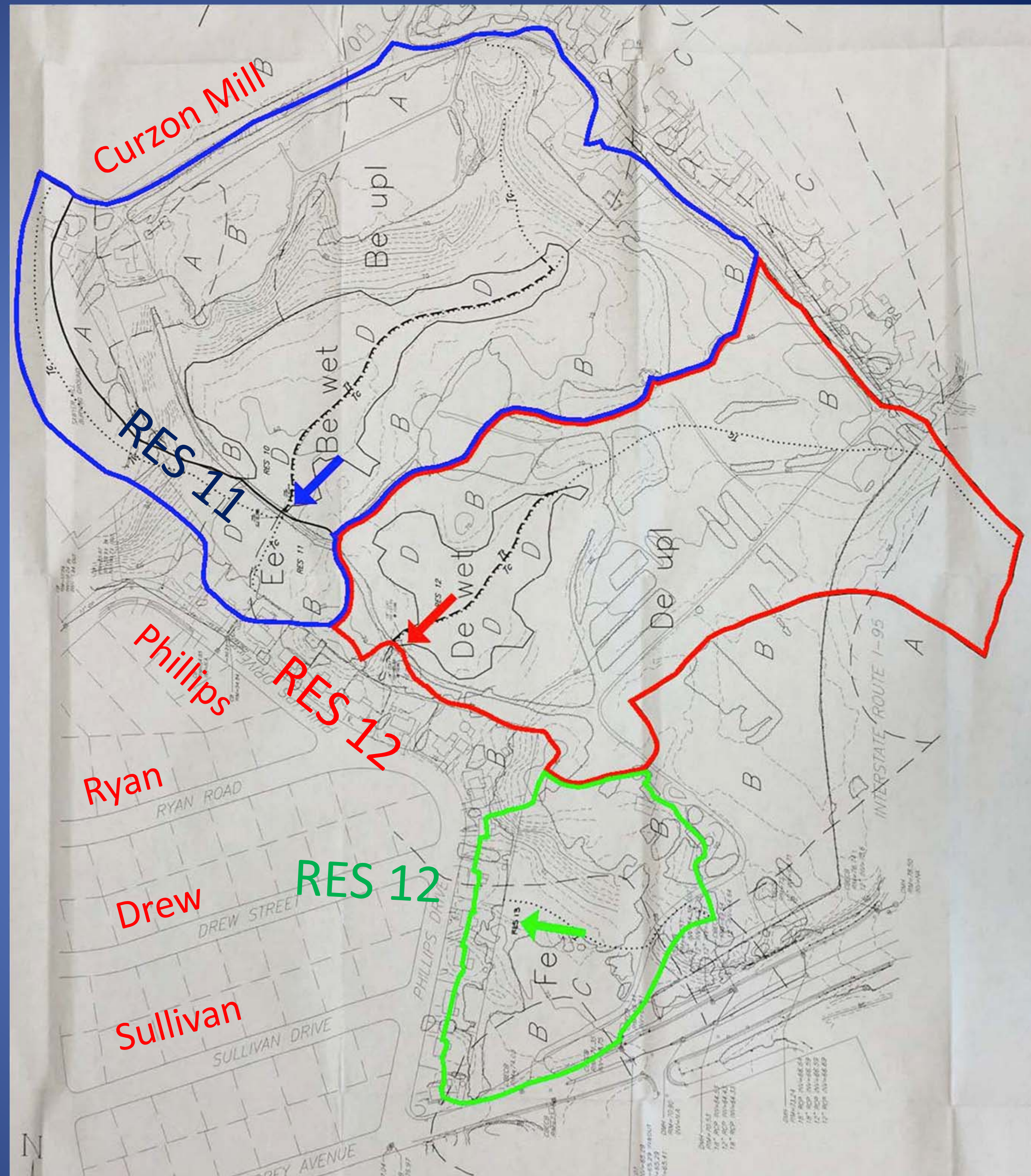
Cherry Hill Development

Pre-Development Stormwater Discharge Points



Cherry Hill Development

Post-Development conditions:

- Developer maintained original 3 drainage discharge locations
- Developer built detention ponds to control the rate of runoff to be *much less* than pre-development conditions

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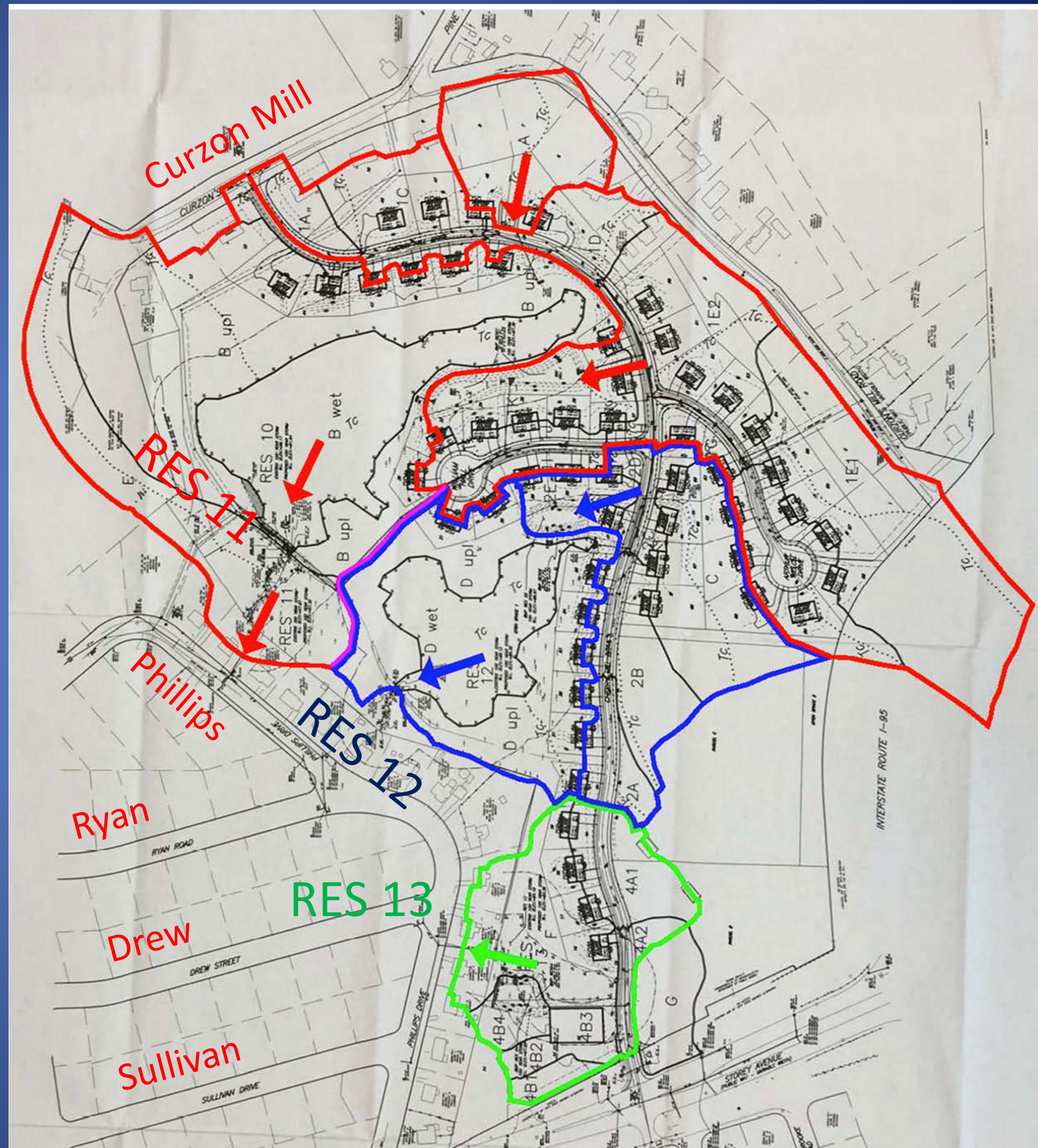
Cherry Hill Development

Post-Development Stormwater Discharge Points



Cherry Hill Development

Post-Development conditions:

- Very difficult to quantify the change to the groundwater condition
- Impossible to determine the change in groundwater condition when no groundwater data was recorded prior to development
- Data would have to be retrieved over many years

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Cherry Hill Development
Storm Water Runoff Flow Rates
Pre- vs. Post-Development

RES 11

PEAK FLOW RATE SUMMARY TO DOWNSTREAM

Storm Event	Existing Condition cfs	Proposed Condition cfs	Change cfs
2 yr. 3.1"/24 hr.	2.4	1.6	- 0.8
10 yr. 4.6"/24 hr.	3.4	3.1	- 0.3
25 yr. 5.4"/24 hr.	9.8	5.3	- 4.5
100 yr. 7.0"/24 hr.	26.1	9.9	- 16.1

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Cherry Hill Development
Storm Water Runoff Flow Rates
Pre- vs. Post-Development

RES 12

PEAK FLOW RATE SUMMARY TO DOWNSTREAM

Storm Event	Existing Condition cfs	Proposed Condition cfs	Change cfs
2 yr. 3.1"/24 hr.	2.3	2.3	0
10 yr. 4.6"/24 hr.	10.1	3.6	- 6.5
25 yr. 5.4"/24 hr.	11.7	4.5	- 7.2
100 yr. 7.0"/24 hr.	13.0	6.2	- 6.8

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Cherry Hill Development
Storm Water Runoff Flow Rates
Pre- vs. Post-Development

RES 13

PEAK FLOW RATE SUMMARY TO DOWNSTREAM

Storm Event	Existing Condition cfs	Proposed Condition cfs	Change cfs
2 yr. 3.1”/24 hr.	2.5	2.2	- 0.3
10 yr. 4.6”/24 hr.	4.3	3.5	- 0.8
25 yr. 5.4”/24 hr.	5.5	4.1	- 1.4
100 yr. 7.0”/24 hr.	6.9	5.3	- 1.6

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CFS to GPM Conversions
For RES 11 Discharge Point

Reduced Flow Rate 100-year Storm:	~16.1 cfs
Gallons per minute:	~7,200 gpm
Typical garden hose*:	10-20 gpm
Typical 4-inch fire hose*:	800 - 1,000 gpm

* Very rough numbers, depends on pressures, hose lengths, etc.

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PRELIMINARY FINDINGS

Primarily Issue #1 – Groundwater:

- Neighborhood was built on tight, clayey, poorly draining soils, resulting in high groundwater conditions
- Cherry Hill Development appears to have detained more runoff than they were required to do and recharged the groundwater appropriately. Need to complete our review.

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PRELIMINARY FINDINGS

Primarily Issue #1 – Groundwater (continued):

- Tree farm reduced runoff and groundwater recharge but it's impractical to determine as to what extent the new development increased groundwater conditions.
- Install impervious dams to slow down flows in pipe trenches
- Investigate perimeter drain(s) behind homes
- Install subdrains in roadway

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PRELIMINARY FINDINGS AND POTENTIAL MITIGATION

Primarily Issue #2 – Surface Flooding:

- Tree farm reduced runoff and groundwater recharge but it’s impractical to determine as to what extent the new development increased groundwater conditions.

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Primary Issue #1
- Groundwater -

- Type C & D soils result in high groundwater conditions and poor infiltration
- Greater chance of basement flooding
- Greater chance of surface flooding because underlying soils are already saturated

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Primary Issue #2
Surface Flooding

- Roadways are designed to handle the 10-year storm event (i.e. 4.5?? " per day)
- Once drainage system is maxed out, then secondary systems come into play

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Primary Issue #2
Surface Flooding

- We’re evaluating the capacity of the Phillips Drive system now.
- Unclear if it’s designed for the 10-year storm. Residents feel it clearly is not.
- Then we’ll evaluate any secondary systems that may exist.

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PRELIMINARY FINDINGS

- Small-scale surface flooding can be resolved with improved roadway construction – defined gutters, curbing, more catch basins
- Large-scale surface flooding can be mitigated with the construction of secondary drainage systems (i.e. swales) in strategic locations

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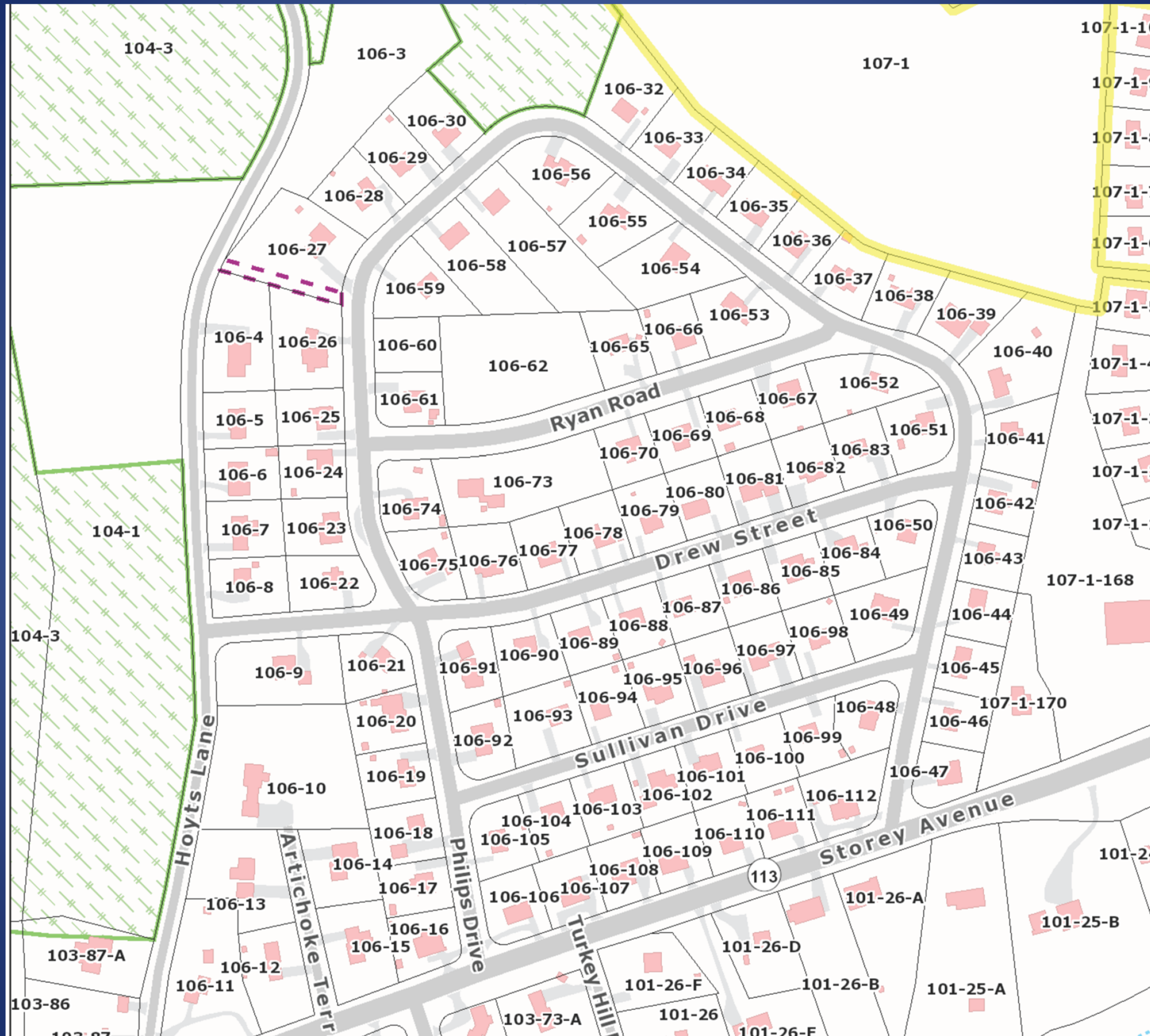
PRIOR RECOMMENDATIONS FROM 2006 FEMA HAZARD MITIGATION GRANT PROGRAM

HIGHLIGHT 3 OPTIONS

PROVIDE OPINIONS



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Ryan Road
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106-16
106-15
103-87-A
106-12
106-11
103-86
103-87
Hoyts Lane
Artichoke Terra
Philips Drive
Turkey Hill R
Storey Avenue
113
101-26-A
101-25-B
101-26-D
101-26-F
101-26-B
101-25-A
101-26
101-26-E
103-73-A
101-24
107-1-10
107-1-9
107-1-8
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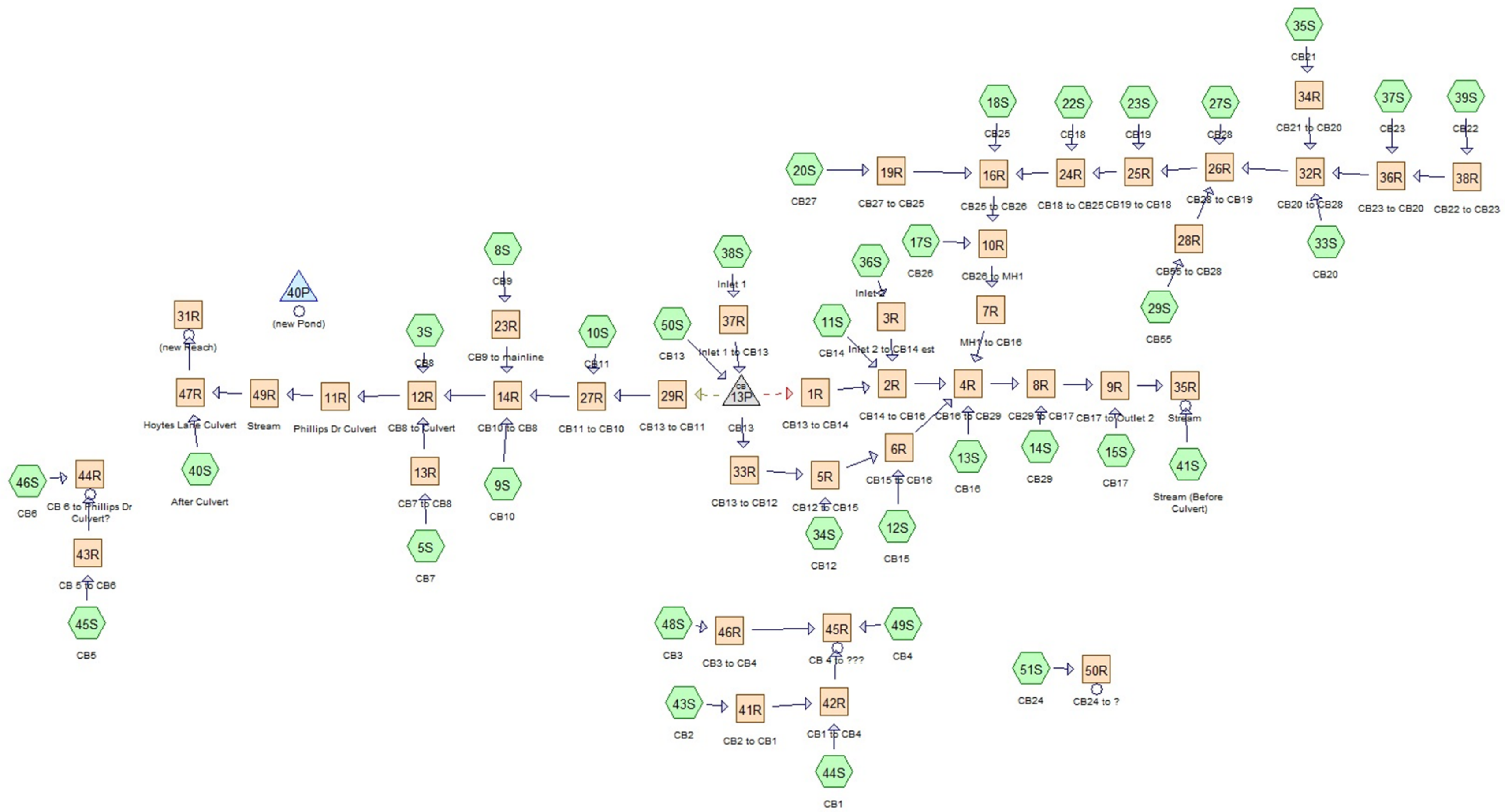

35S
CB21
34R
CB21 to CB20
37S
CB23
39S
CB22
18S
CB25
22S
CB18
23S
CB19
27S
CB28
20S
CB27
19R
CB27 to CB25
16R
CB25 to CB26
24R
CB18 to CB25
25R
CB19 to CB18
26R
CB28 to CB19
32R
CB20 to CB28
36R
CB23 to CB20
38R
CB22 to CB23
33S
CB20
28R
CB55 to CB28
29S
CB55
17S
CB26
10R
CB26 to MH1
7R
MH1 to CB16
36S
Inlet 2
3R
Inlet 2 to CB14 est
38S
Inlet 1
37R
Inlet 1 to CB13
8S
CB9
23R
CB9 to mainline
40P
(new Pond)
31R
(new Reach)
3S
CB8
10S
CB11
50S
CB13
11S
CB14
47R
Hoytes Lane Culvert
49R
Stream
11R
Phillips Dr Culvert
12R
CB8 to Culvert
14R
CB10 to CB8
27R
CB11 to CB10
29R
CB13 to CB11
13P
CB13
1R
CB13 to CB14
2R
CB14 to CB16
4R
CB16 to CB29
8R
CB29 to CB17
9R
CB17 to Outlet 2
35R
Stream
40S
After Culvert
13R
CB7 to CB8
9S
CB10
5S
CB7
33R
CB13 to CB12
5R
CB12 to CB15
6R
CB15 to CB16
13S
CB16
14S
CB29
15S
CB17
41S
Stream (Before Culvert)
34S
CB12
12S
CB15
46S
CB6
44R
CB 6 to Phillips Dr Culvert?
43R
CB 5 to CB6
45S
CB5
48S
CB3
46R
CB3 to CB4
45R
CB 4 to ???
49S
CB4
51S
CB24
50R
CB24 to ?
43S
CB2
41R
CB2 to CB1
42R
CB1 to CB4
44S
CB1