Kearney Post-Construction Stormwater Program

Stormwater Treatment Calculations

Kearney – Public Works Office

August 10 and 17, 2017

Stormwater Treatment Hydrology
Goals

- Understand Rainfall vs Runoff
- Understand Calculations
- Apply Equations to Example
- Explore Other Design Considerations

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NEBRASKA H_2O

General Approach

- Determine rainfall amount
  - 80% rainfall event (Region B - Central Region) for New Development
  - 70% rainfall event (Region B - Central Region) for Redevelopment
- Calculate runoff volume and/or rate for the rainfall amount based on % impervious

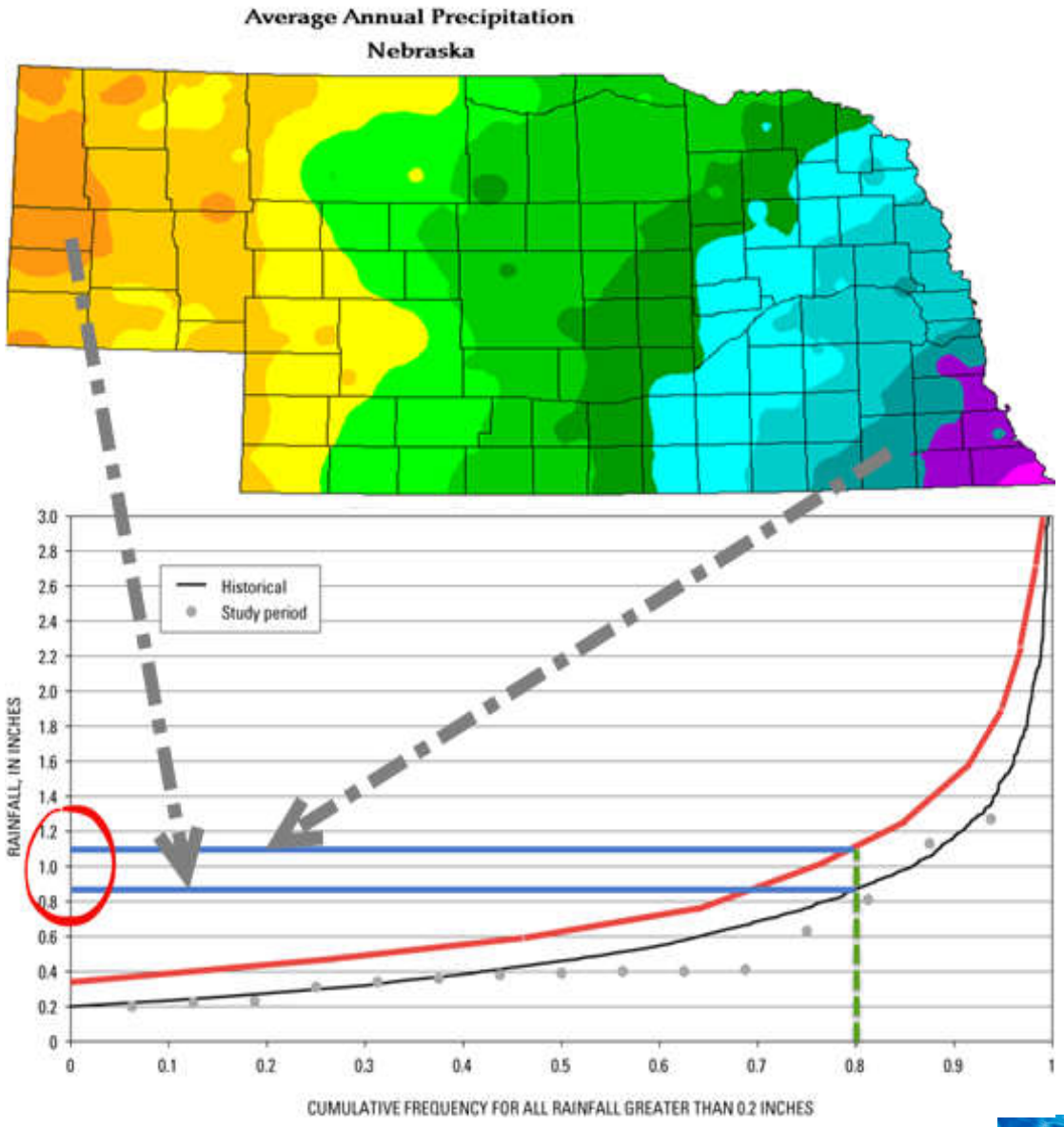
Rainfall

Terms that influence discussion about Rainfall include:

- Rainfall

- Geographic Distribution

- Percentile Storm Event



Rainfall

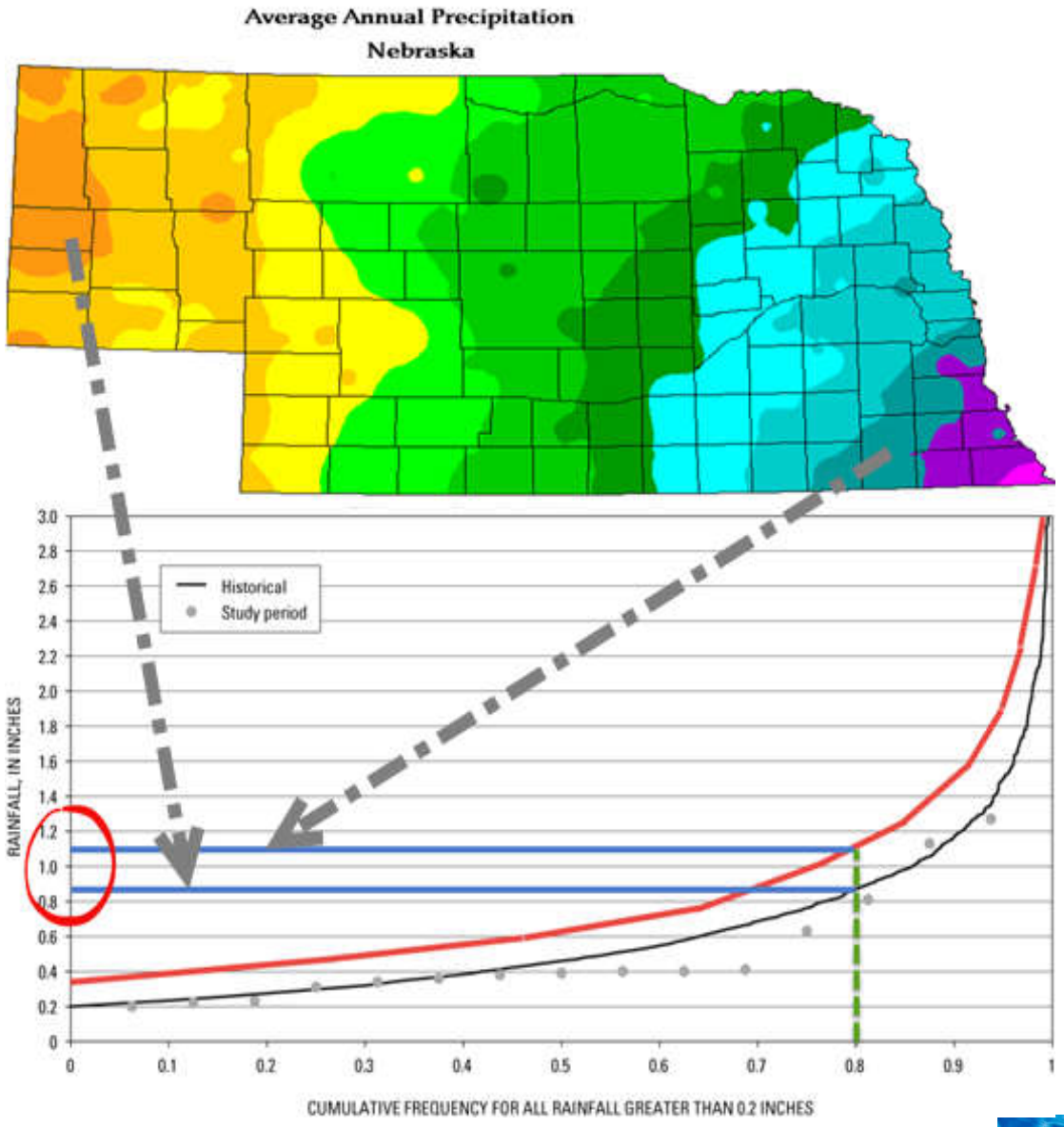
Terms that influence discussion about Rainfall include:

- Rainfall

- Geographic Distribution

- Percentile Storm Event

For lower curve:
0.5” => 55% storm event
1.0” => 86% storm event
1.5” => 96% storm event



Runoff

Terms that influence discussion about Runoff include:

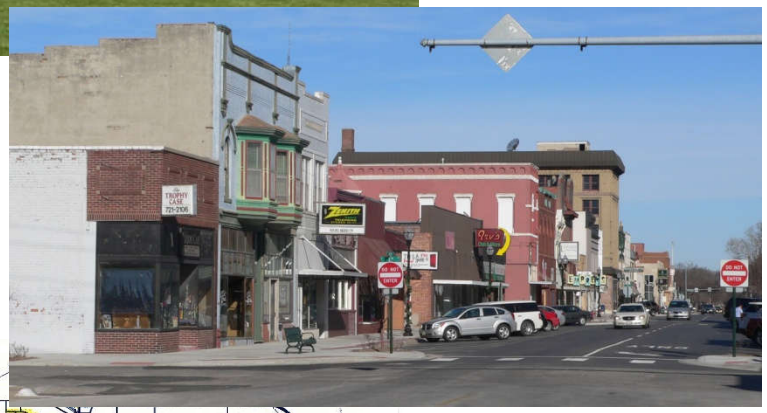
- **Impervious Cover**

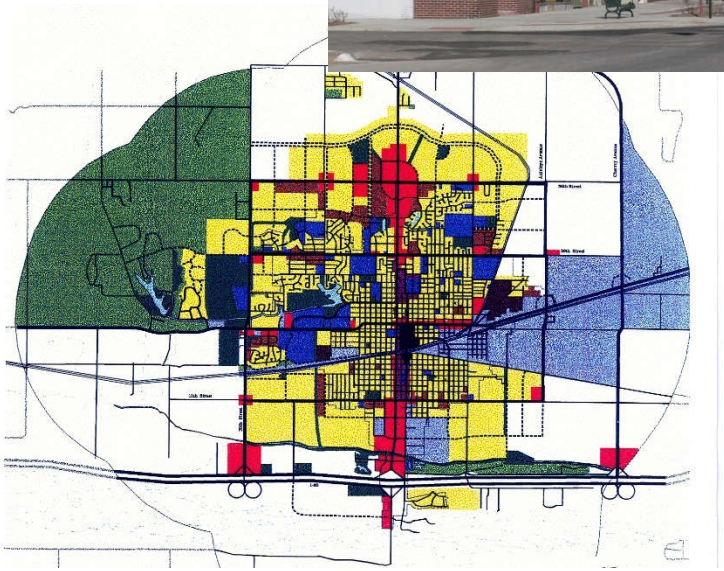
- **Land Use**

- Soil Type

- Disconnected Imperviousness

- Time of Concentration





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- **Soil Type**

- **Disconnected Imperviousness**

- **Time of Concentration**

Stormwater Treatment

EPA Performance Standard

- Protect and restore the physical, chemical and biological integrity of receiving waters
- Treat flow (volume) as a surrogate for other pollutants
- Replicate pre-development hydrology

Problem

- Runoff carries pollutants with it
- Volume of runoff has increased

Solution

- Provide treatment
- Reduce runoff

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Stormwater Treatment Calculations

WQCV

For STFs that function based on a **volume** held for a set amount of time (i.e. rain gardens, bioretention basins, ponds)

Water Quality Volume Discharge Rate (Qwq)

For STFs that function based on **flow rate** (i.e. swales, filter strips, manufactured systems…etc)

WQCV Calculations

WQCV= P x (0.05+0.009 x %imp) x A x 1/12 x 43,560

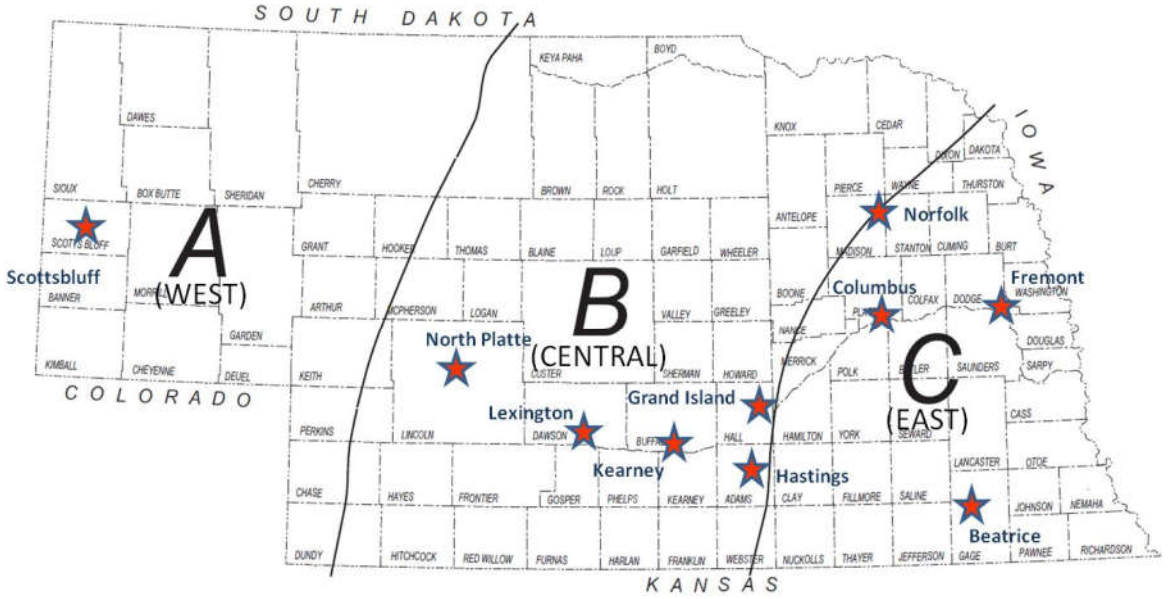
Where,

P = rainfall depth, in

A = treatment drainage area, ac

%imp = maximum percent imperviousness (expressed as a whole number not as a decimal) for proposed zoning types (use maximum impervious %)

P = Rainfall Depth



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Adapted from NDOR Drainage and Erosion Control Manual Ch. 1

Applicable Region	Rainfall, P	
	80th Percentile Event (New Development)	70th Percentile Event (Redevelopment)
A (West)	0.61”	0.44”
B (Central)	**0.72”**	**0.53”**
C (East)	0.83”	0.62”

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A = Treatment Drainage Acres

The ‘Treatment Drainage Area’ shall include all disturbed areas on the site. Any “runon” from upstream drainage must be accounted for in treatment OR rerouted around the STF’s.

%imp = Maximum Impervious Coverage

"This measures the percentage of a site that may be covered by buildings and other surfaces and development features which prevent the penetration of water into the ground (Such as driveways, porches, parking lots, and other features). Limits on impervious coverage help control the velocity and quantity of stormwater runoff and provide for groundwater recharge."

-Chapter 14 City Code

	Maximum Impervious Percentage	
City Code Chapter	Zoning Use Class	%
15	AG Agricultural District	NA
16	RR-1 Rural Residential	NA
18	RR-2 Rural Residential	30%
19	R-1 Urban Residental	45%
20	R-2 Urban Residential	55%
21	R-3 Urban Residential	55%
22	R-4 Urban Residential	55%
23	RM Mobile Home Res.	60%
24	UC Mixed Use Urban	70%
25	C-O Office District	80%
26	C-1 Limited Commercial	80%
27	C-2 Community Commercial	80%
28	CBD Center Mixed Use District	100%
29	C-3 General Commercial	90%
30	BP Business Park	80%
31	M-1 Limited Industrial	90%
32	M-2 General Industrial	90%
42	ND-1 Pioneer Park	70%

For multiple land uses within the treatment drainage area:

Effective maximum % imperviousness should be pro-rated based on the area of each zone as a % of the total area.

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Water Quality Volume Discharge Rate (Qwq)

The Q_{WQ} is the peak runoff from the design water quality rainfall event. The calculation is based on:

- the 80th percentile rain event depth by region
- a 24 hour duration storm event
- a time of concentration of 5 minutes

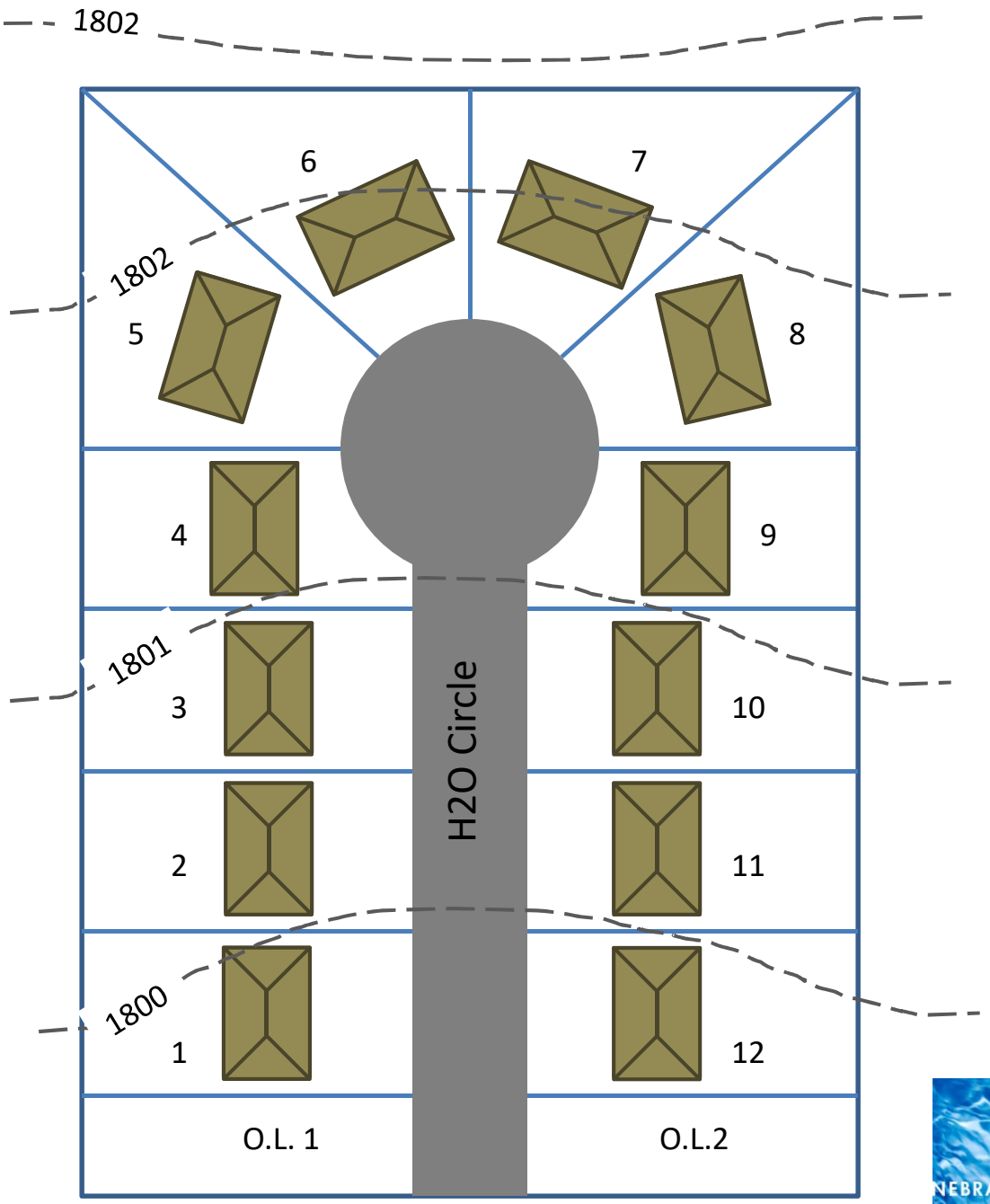
The area used is the **impervious surface** only within the treatment drainage area.

Water Quality Volume Discharge Rate (Qwq)

Impervious Area (Acres)	Q_{WQ} (cfs) West | Central | East	Impervious Area (Acres)	Q_{WQ} (cfs) West | Central | East	Impervious Area (Acres)	Q_{WQ} (cfs) West | Central | East
0.2	0.1 | 0.2 | 0.2	2.2	1.5 | 1.9 | 2.2	4.2	2.9 | 3.6 | 4.2
0.4	0.3 | 0.3 | 0.4	2.4	1.6 | 2.0 | 2.4	4.4	3.0 | 3.7 | 4.4
0.6	0.4 | 0.5 | 0.6	2.6	1.8 | 2.2 | 2.6	4.6	3.2 | 3.9 | 4.6
0.8	0.5 | 0.7 | 0.8	2.8	1.9 | 2.4 | 2.8	4.8	3.3 | 4.1 | 4.8
1.0	0.7 | 0.8 | 1.0	3.0	2.1 | 2.5 | 3.0	5.0	3.4 | 4.2 | 5.0
1.2	0.8 | 1.0 | 1.2	3.2	2.2 | 2.7 | 3.2	5.2	3.6 | 4.4 | 5.2
1.4	1.0 | 1.2 | 1.4	3.4	2.3 | 2.9 | 3.4	5.4	3.7 | 4.6 | 5.4
1.6	1.1 | 1.4 | 1.6	3.6	2.5 | 3.0 | 3.6	5.6	3.8 | 4.7 | 5.6
1.8	1.2 | 1.5 | 1.8	3.8	2.6 | 3.2 | 3.8	5.8	4.0 | 4.9 | 5.8
2.0	1.4 | 1.7 | 2.0	4.0	2.7 | 3.4 | 4.0	6.0	4.1 | 5.1 | 6.0

Design Example 1
Single Family Residential

- Developer wants to build 12 single family residential lots on 4 acres in Kearney (Central Region)
- New Development
- Platted as medium-density (say R3)



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WQCV = P x (0.05+0.009 x %imp) x A x 1/12 x 43,560

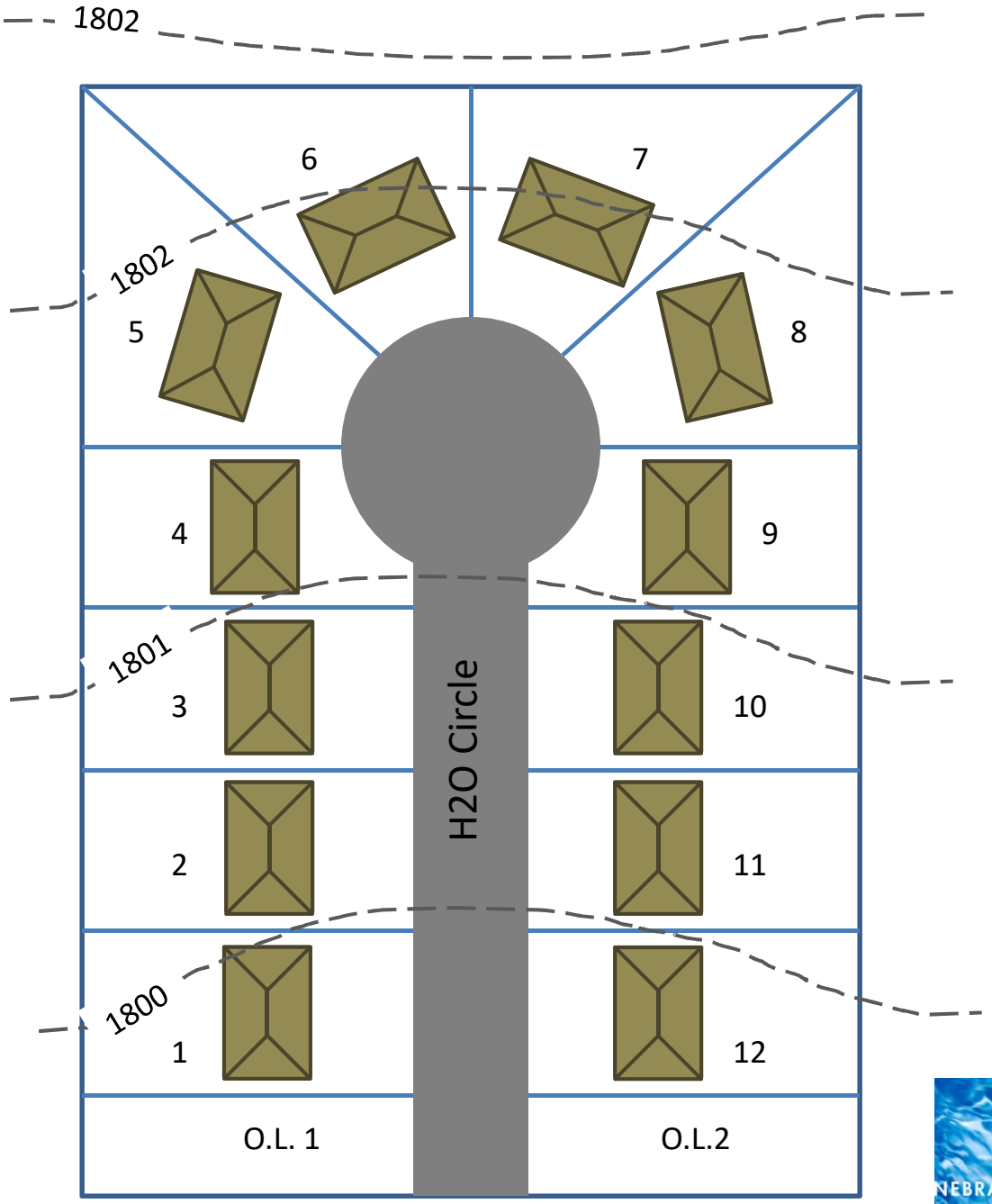
Where,

P = rainfall depth (new 0.72" ; re 0.53")

A = treatment drainage area in acres

%imp = maximum percent imperviousness (expressed as a whole number, not decimal)

(use max % impervious for proposed zoning type)



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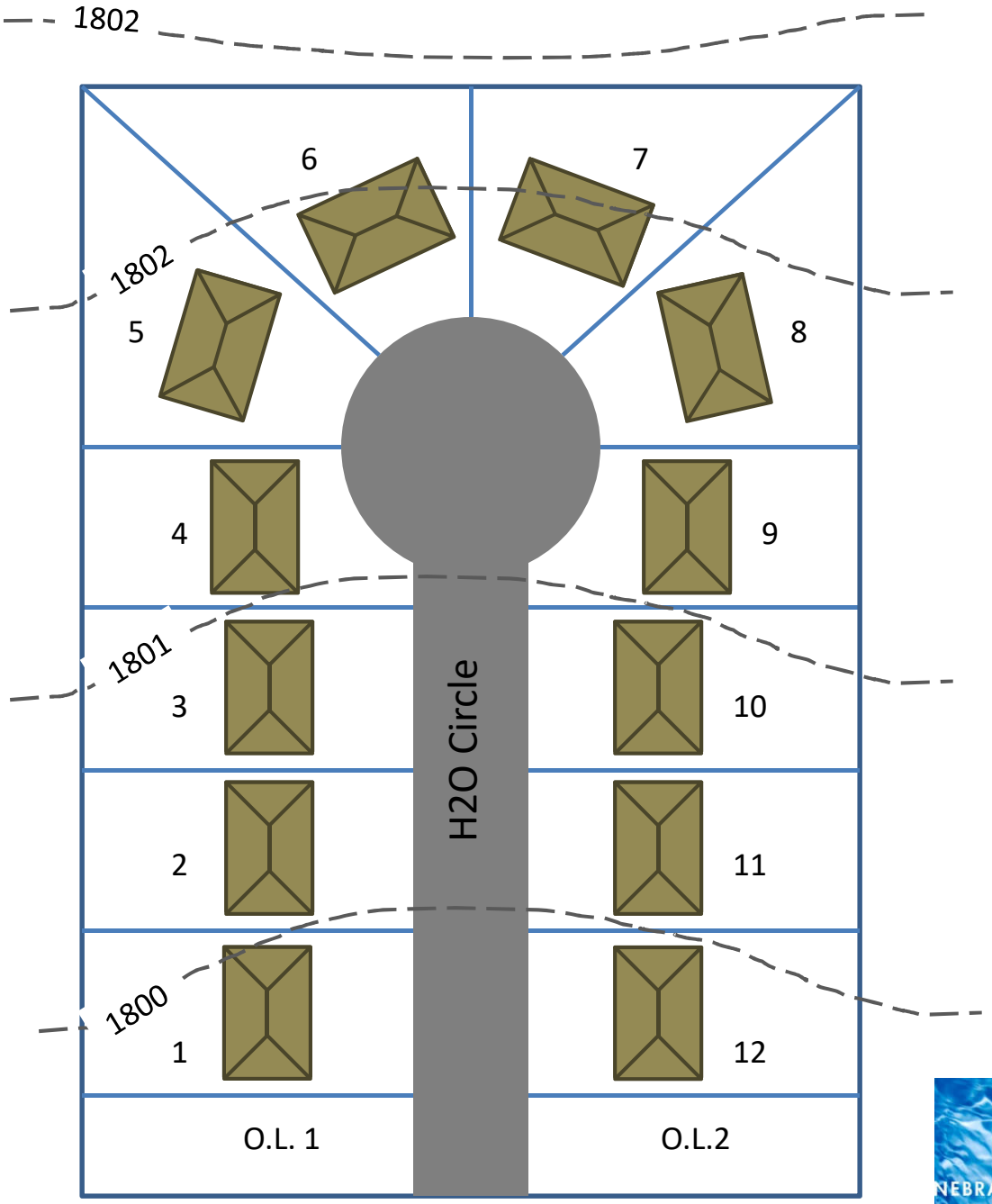
P = 0.72" (new)



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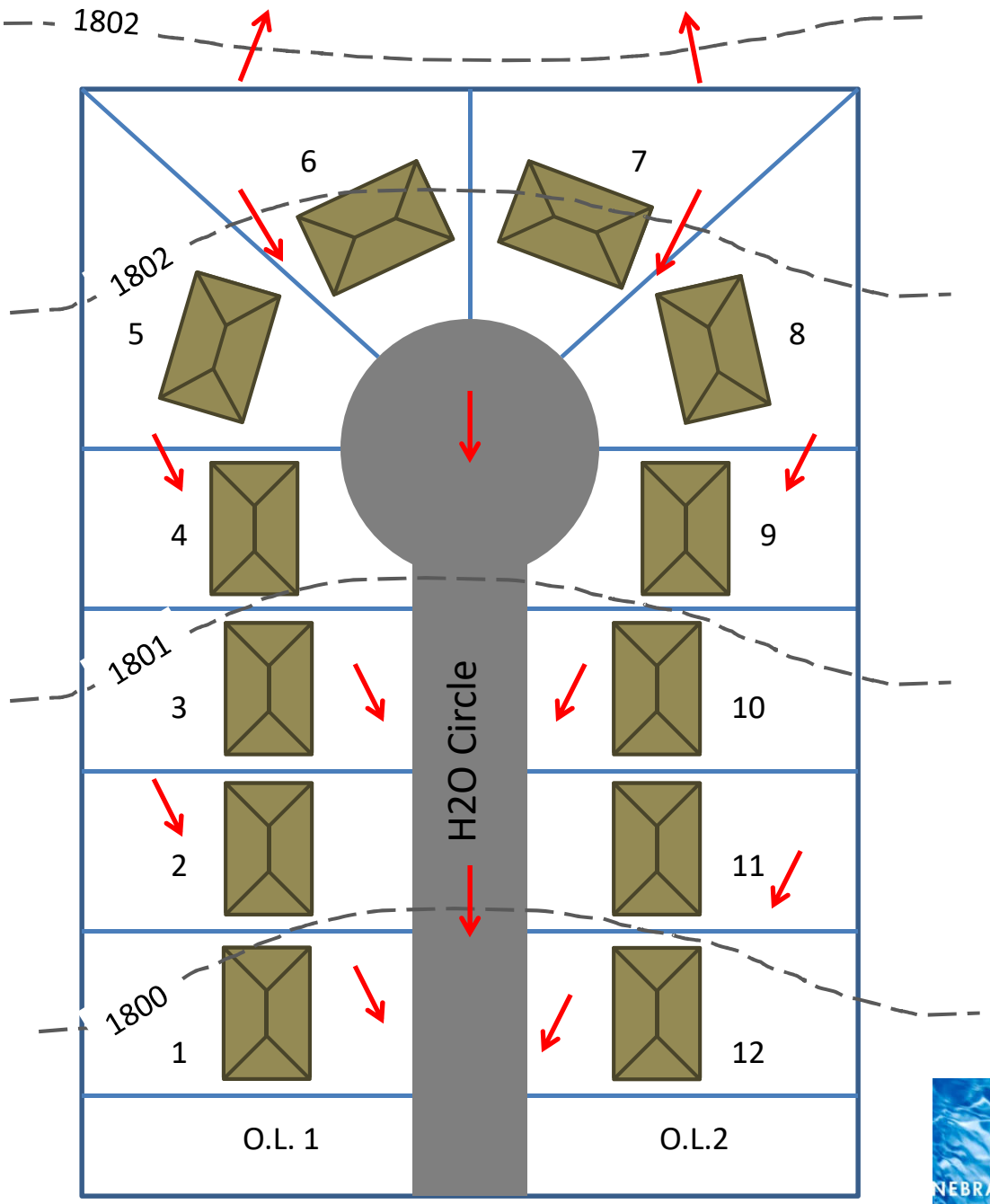

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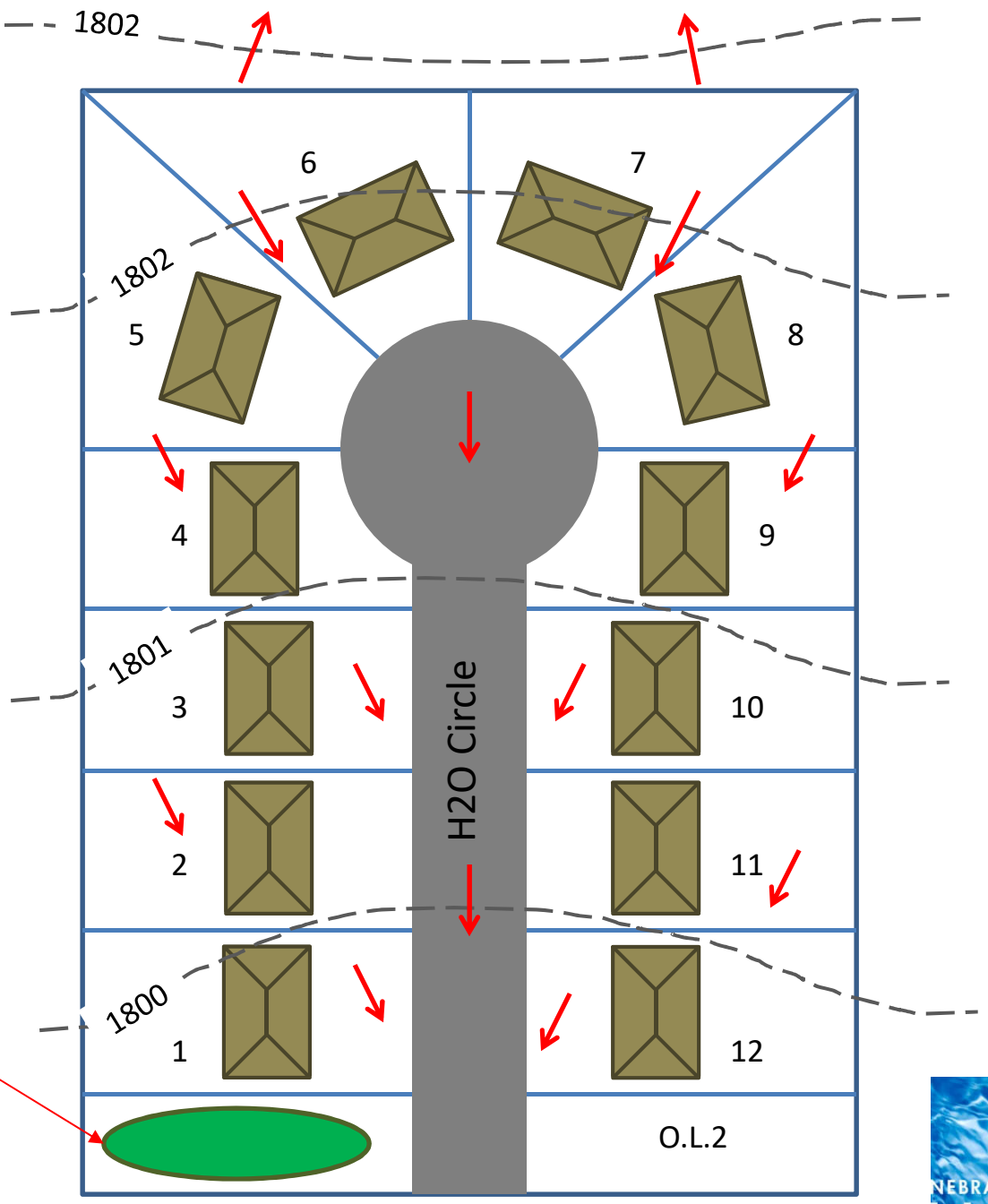
Treatment Location



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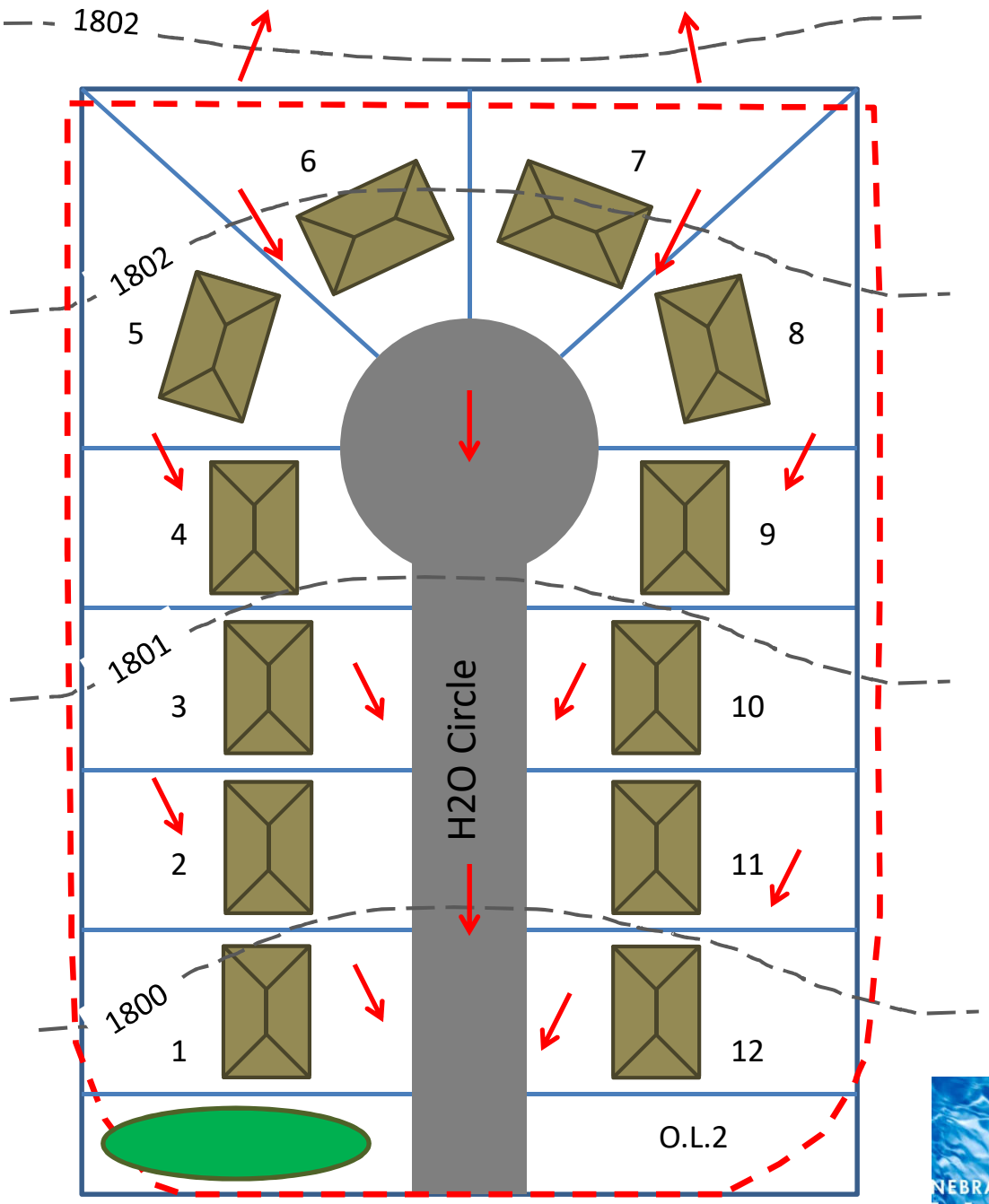
A = 4 acres (shown)



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NEBRASKA H2O

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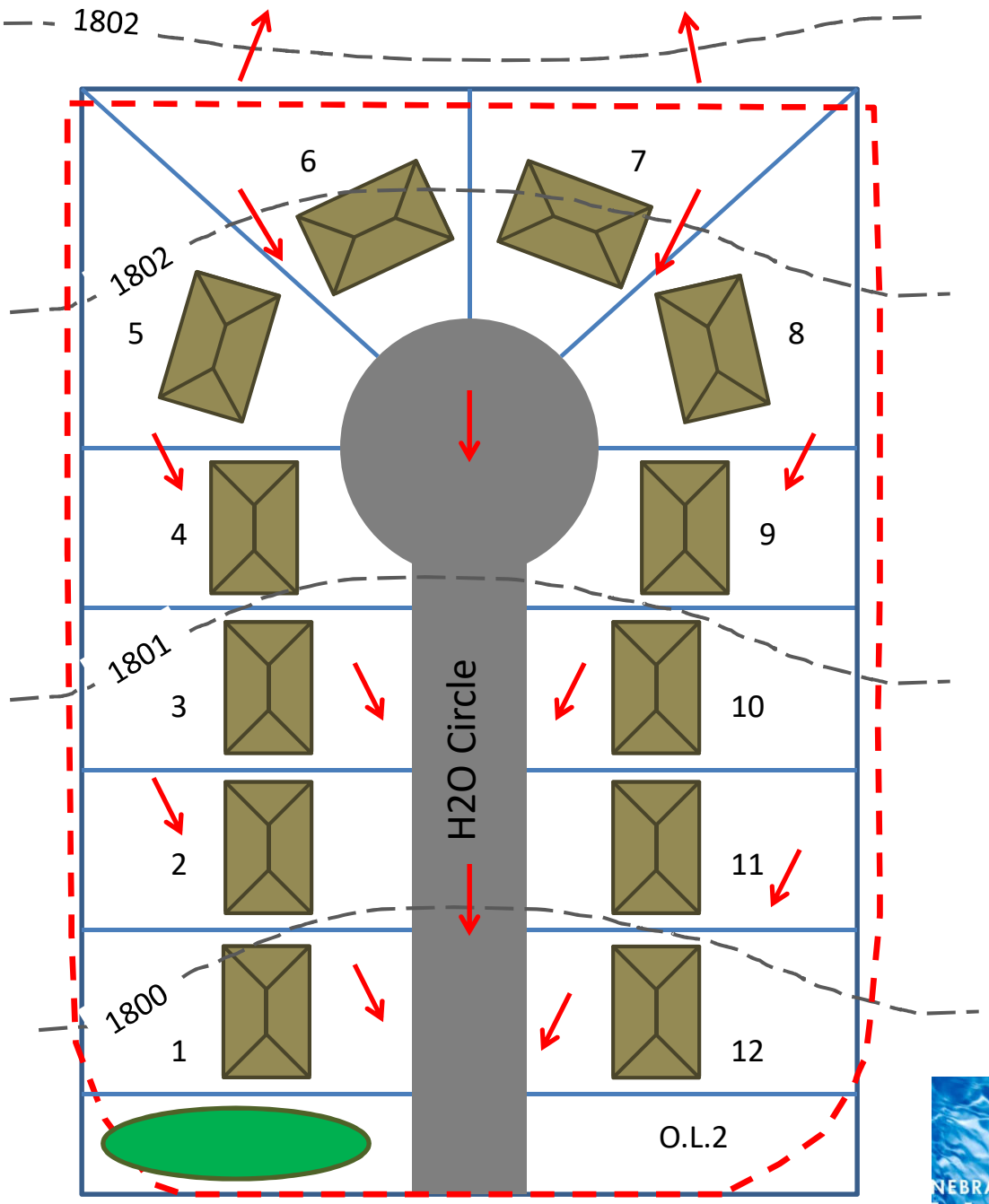
WQCV = P x (0.05+0.009 x %imp) x A x 1/12 x 43,560

P = 0.72" (new)

A = 4 acres (shown)

%Imp = 55 (for R3, from Table)



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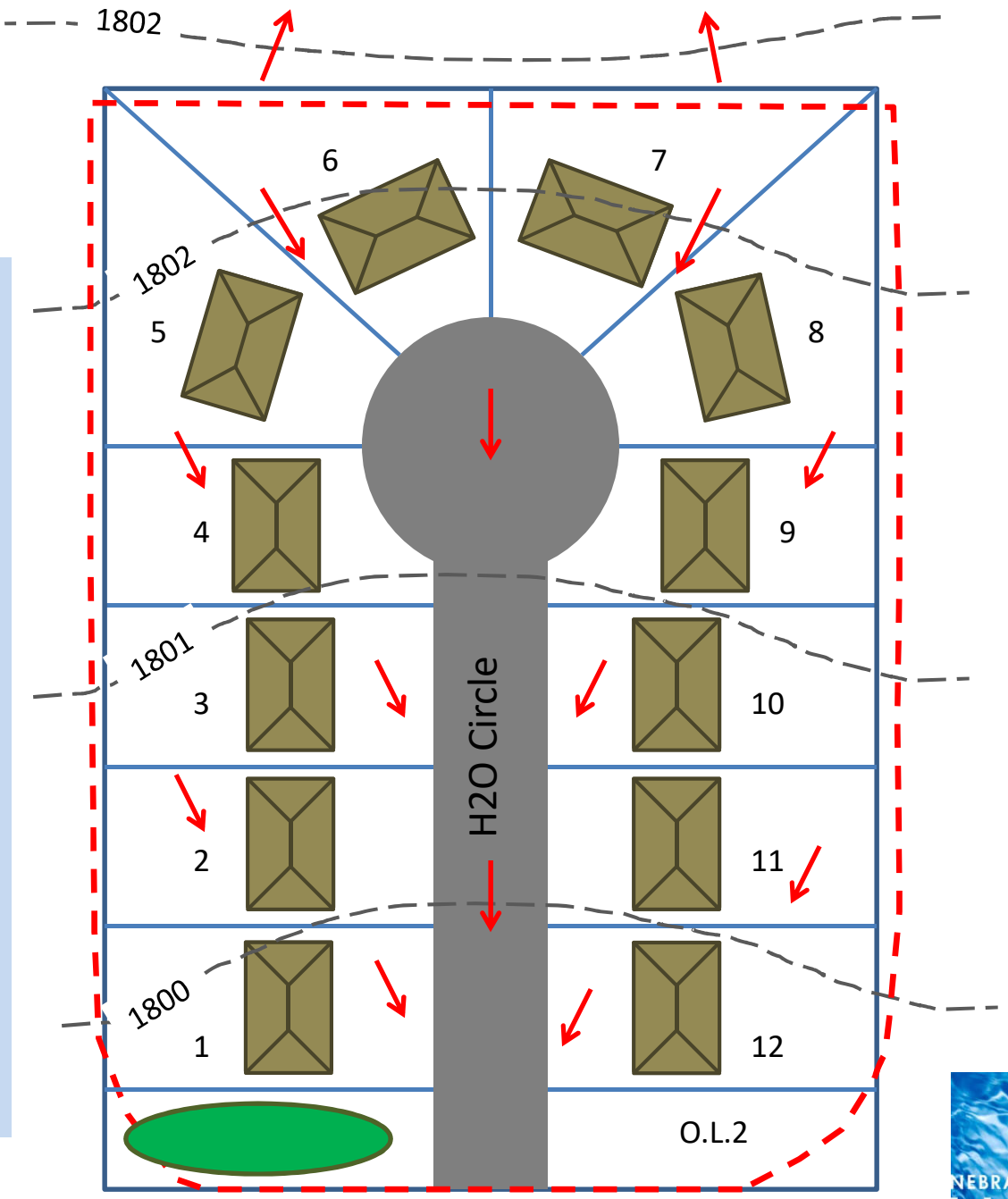
P = 0.72" (new)

A = 4 acres (shown)

%Imp = 55 (for R3, from Table)

WQCV=**0.72"** x (0.05+0.009 x **55**) x (**4.0** ac) x 1/12 x 43,560 = ***5,698 cubic feet.***



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- Developer wants to build 12 single family residential lots on 4 acres in Kearney (Central Region)
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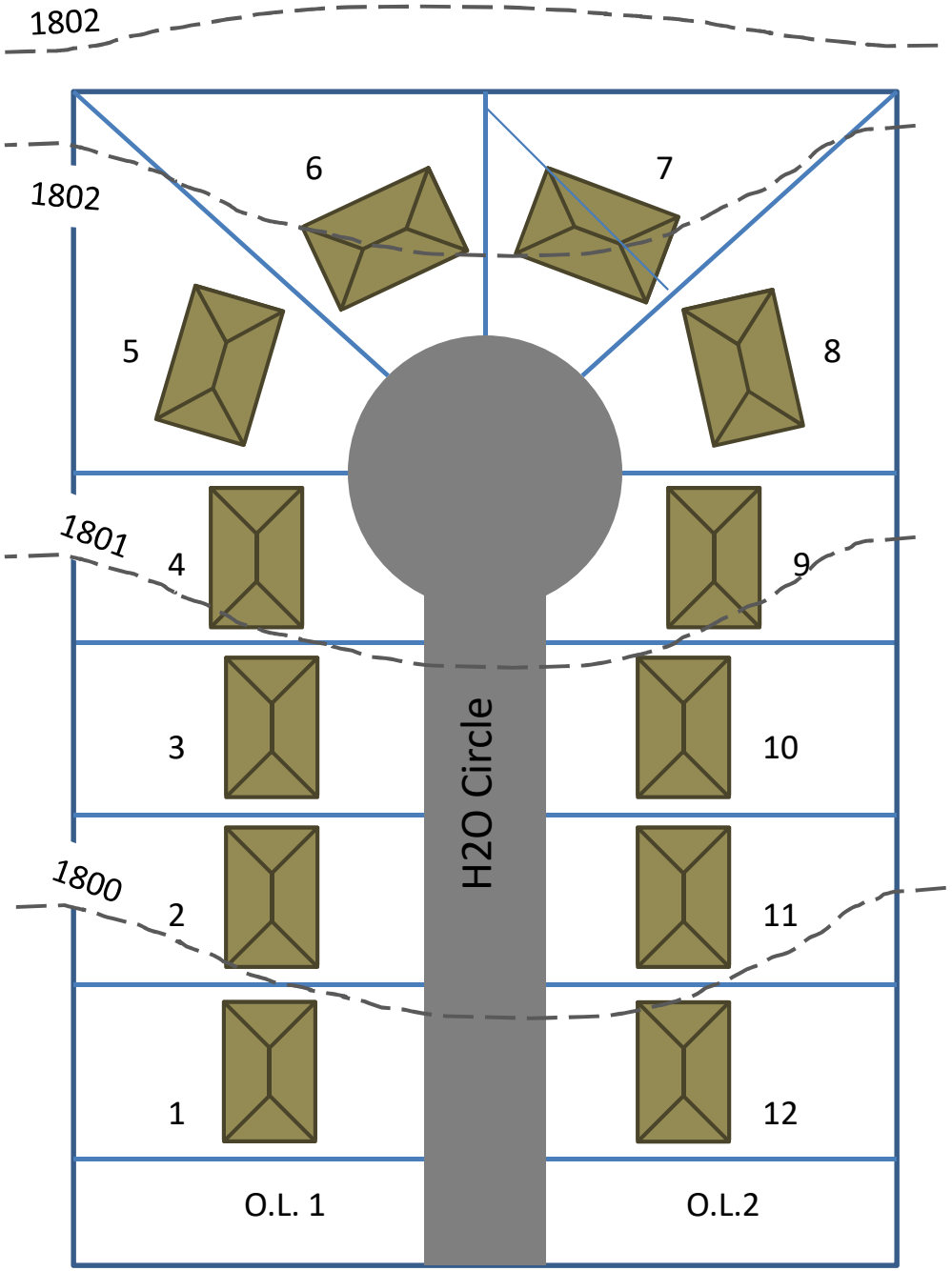

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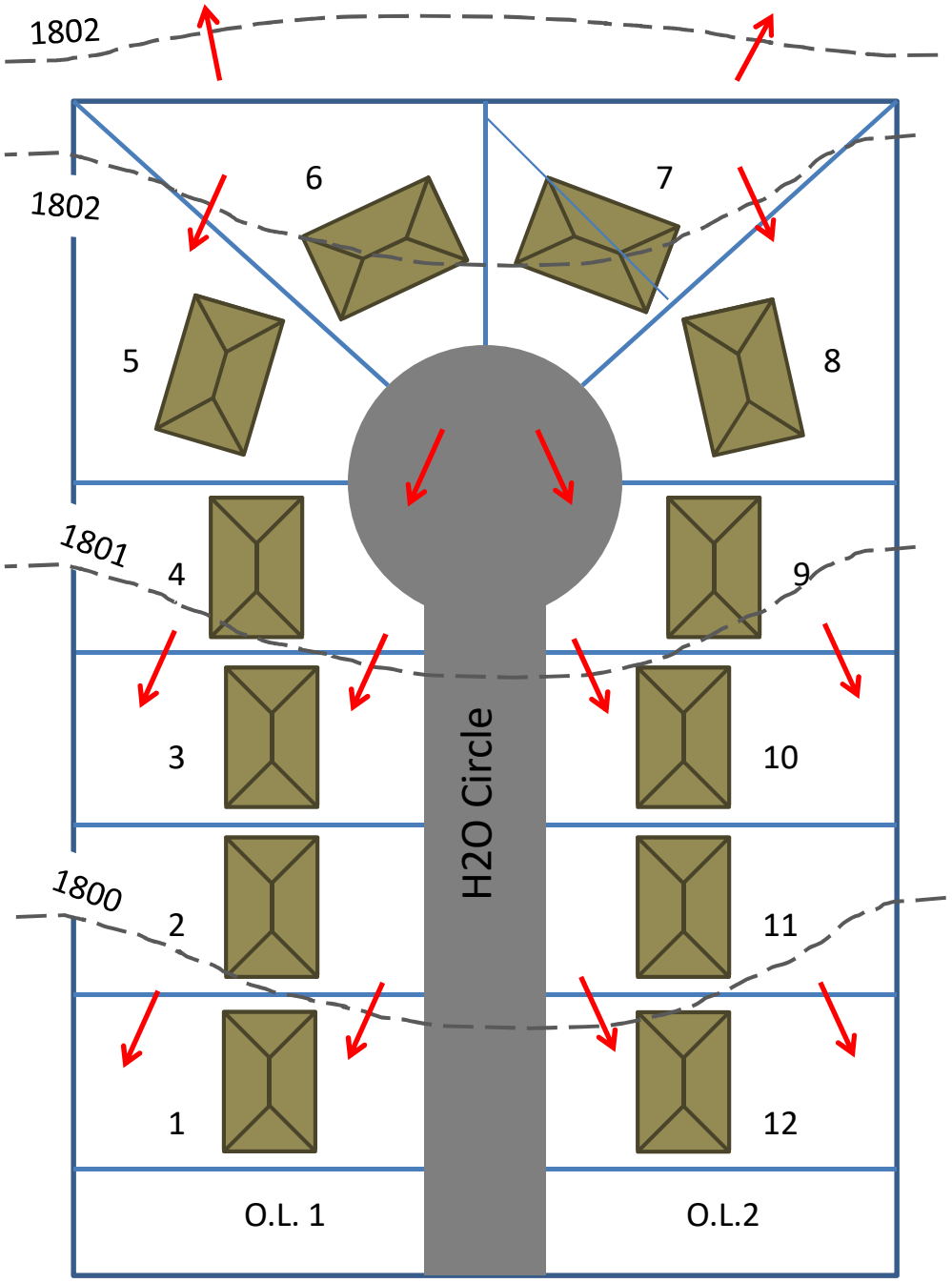

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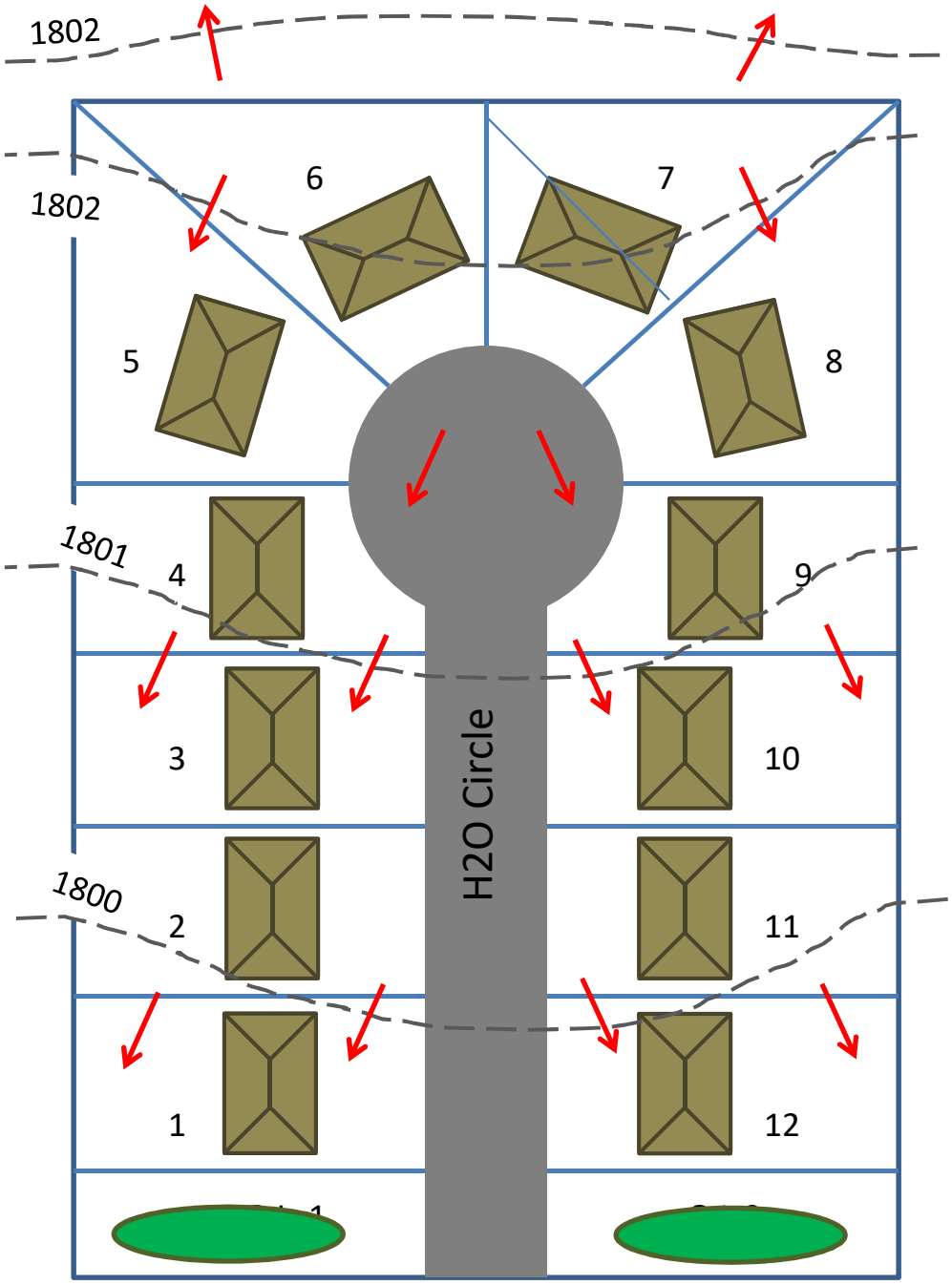

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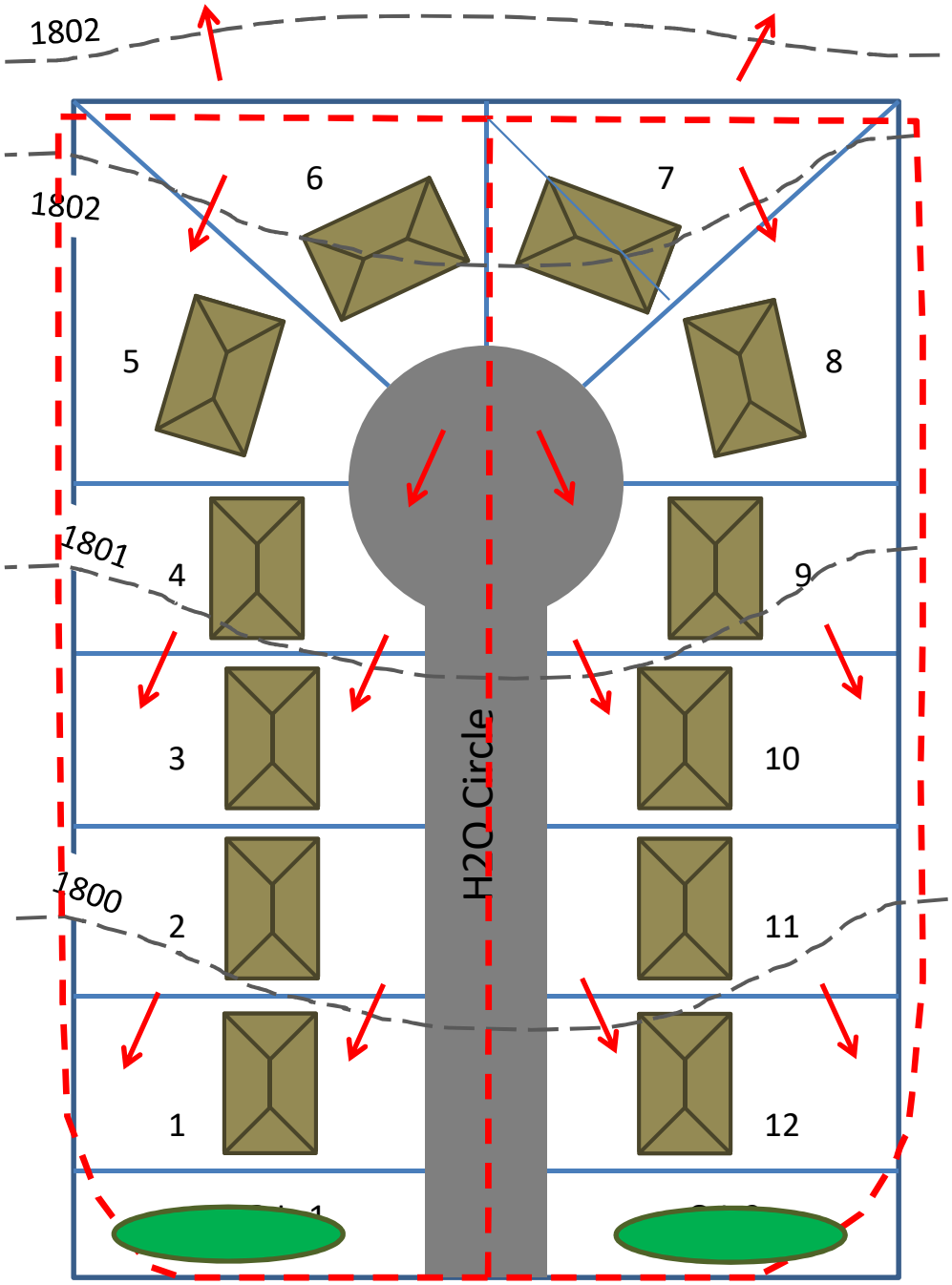

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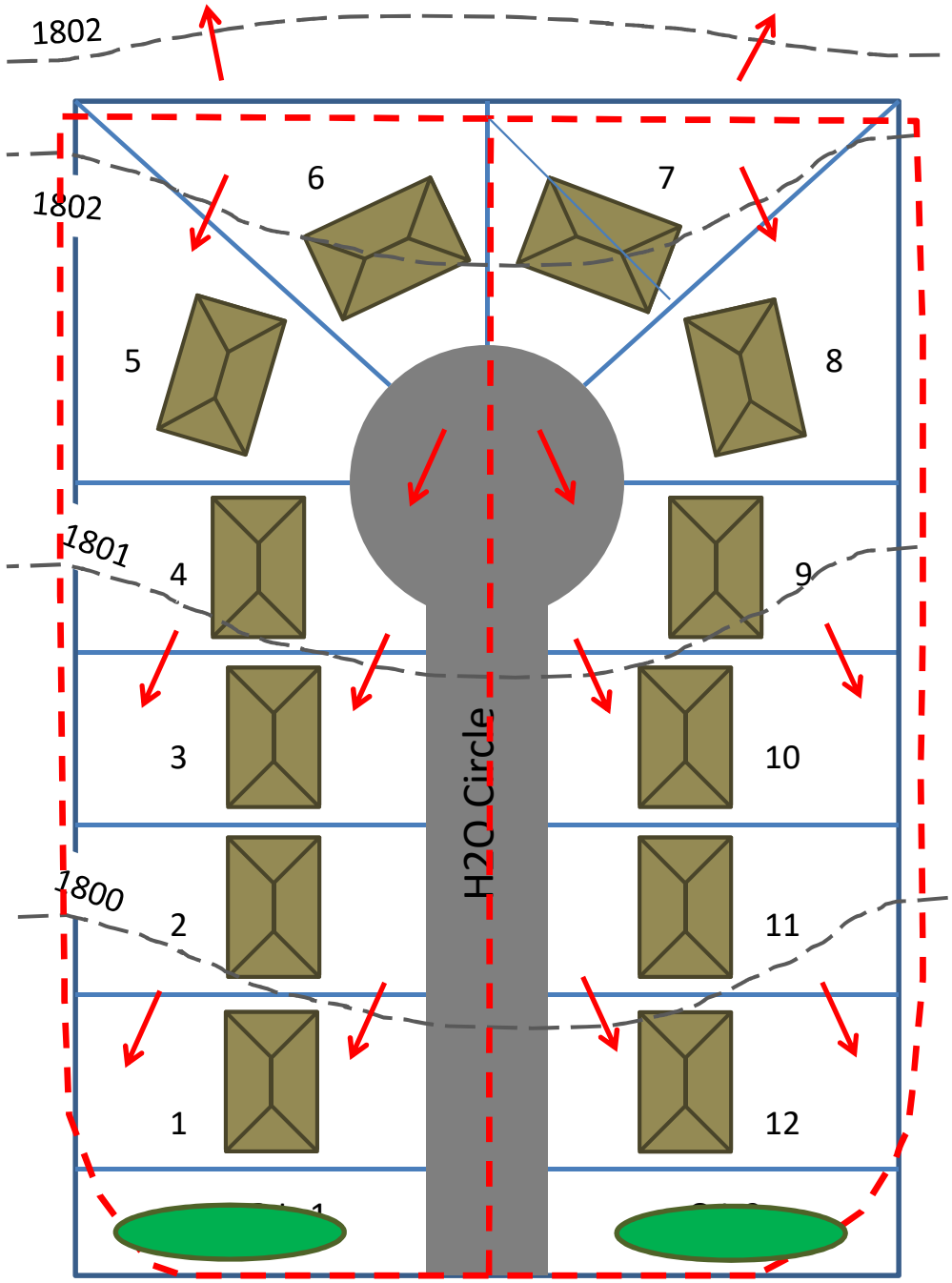
WQCV = P x (0.05+0.009 x %imp) x A x 1/12 x 43,560

P = 0.72" (new)

A = 2 acres (each area shown)

%Imp = 55 (for R3, from Table)

WQCV= **0.72"** x (0.05+0.009 x **55**) x (**2.0** ac) x 1/12 x 43,560 = ***2,849 cubic feet (for each drainage area).***



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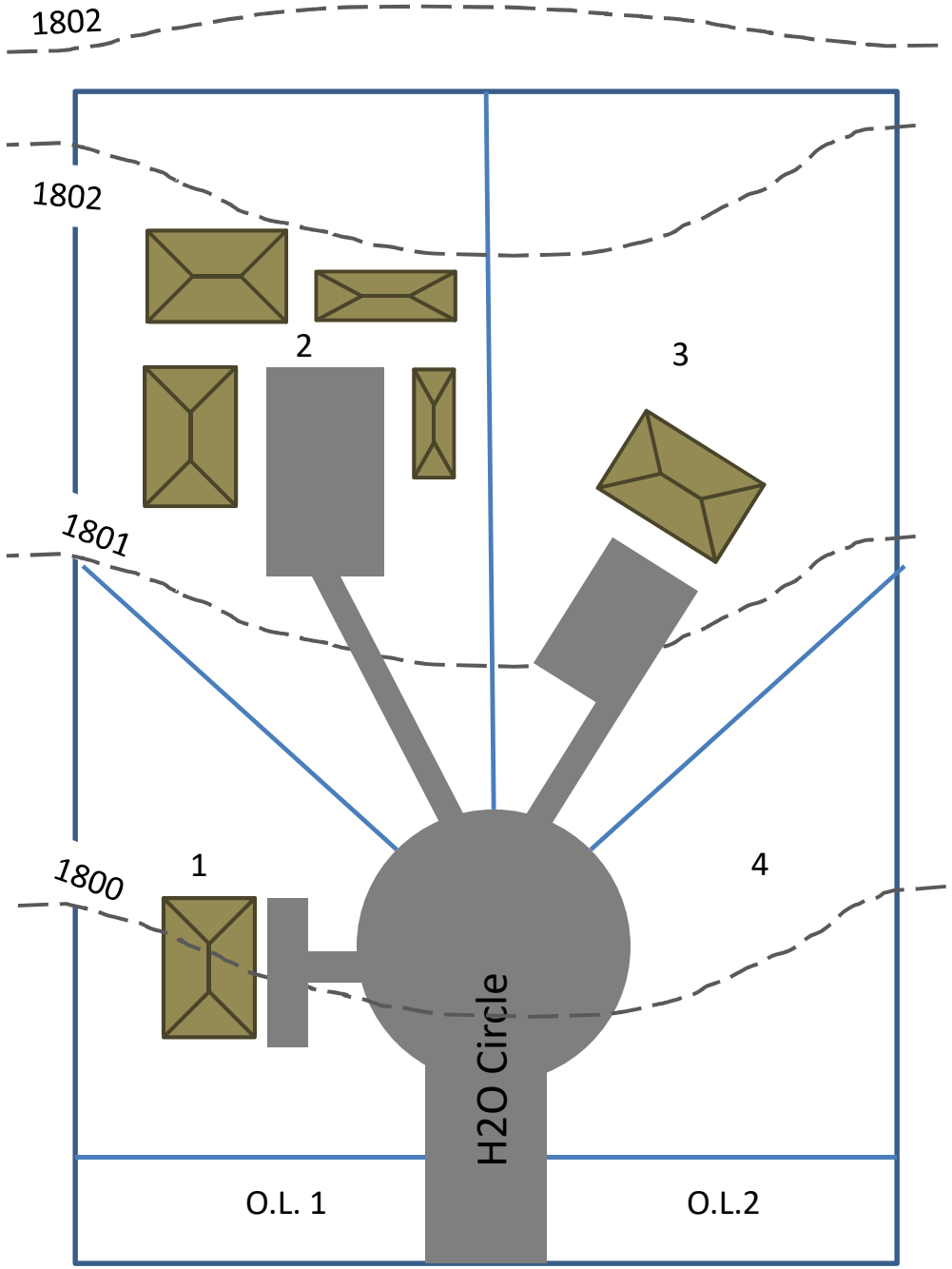
Design Example - Commercial

- Developer wants to build 4 commercial lots on 4 acres in Kearney (Central Region)
- New Development
- Platted as limited commercial (say C-1)



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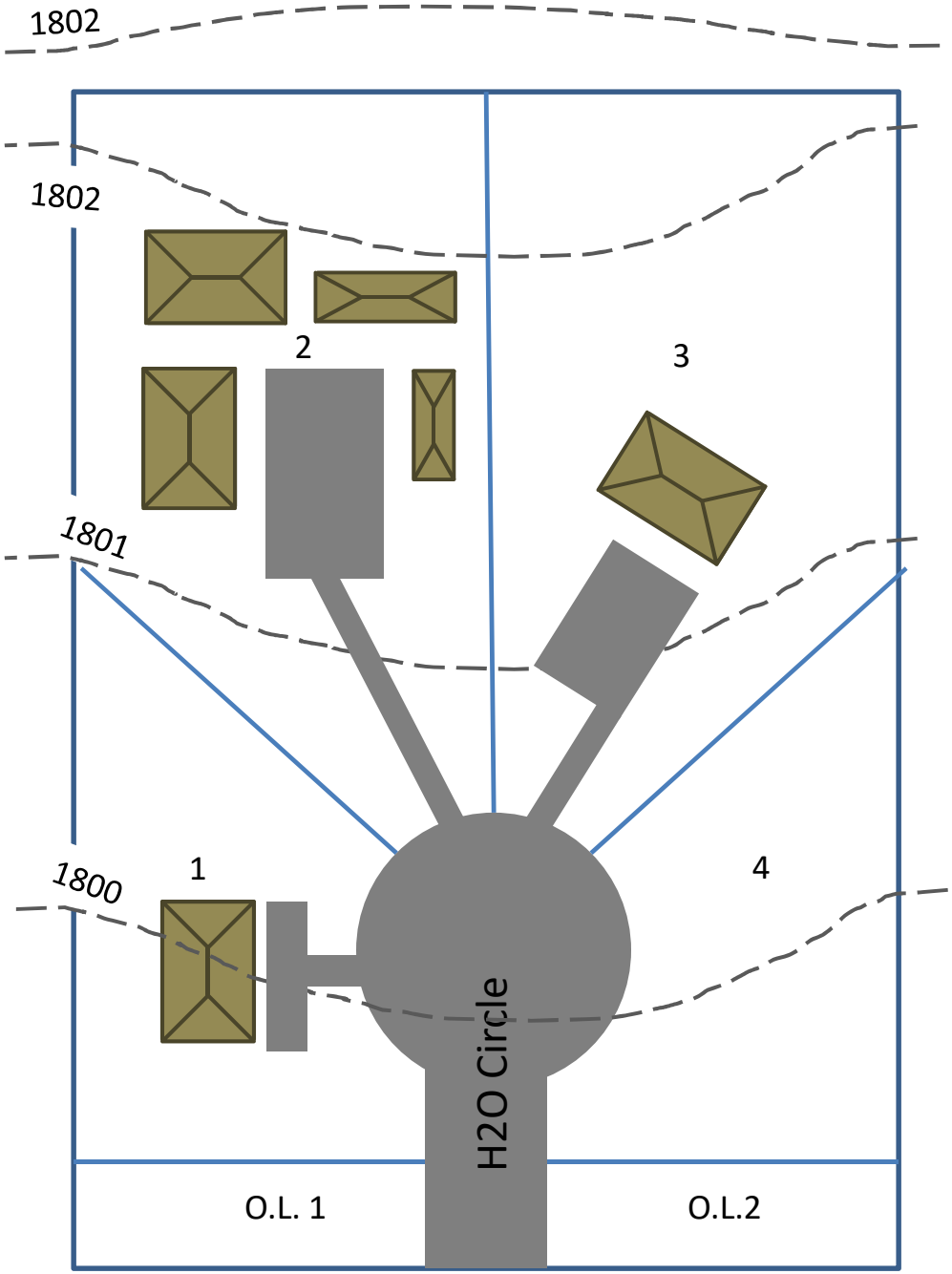
CONSIDER NEIGHBORHOOD SCALE VS. LOT SCALE



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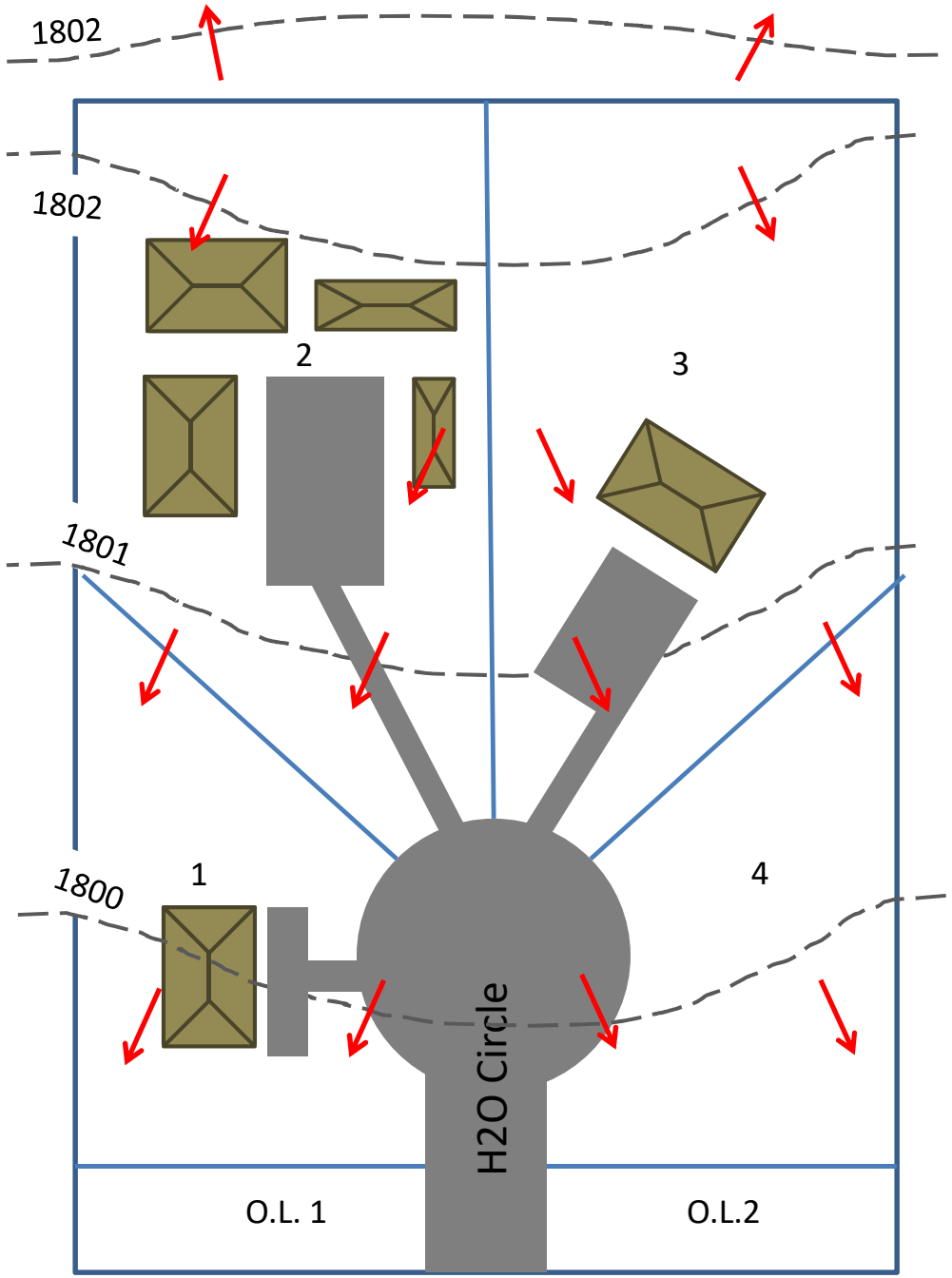

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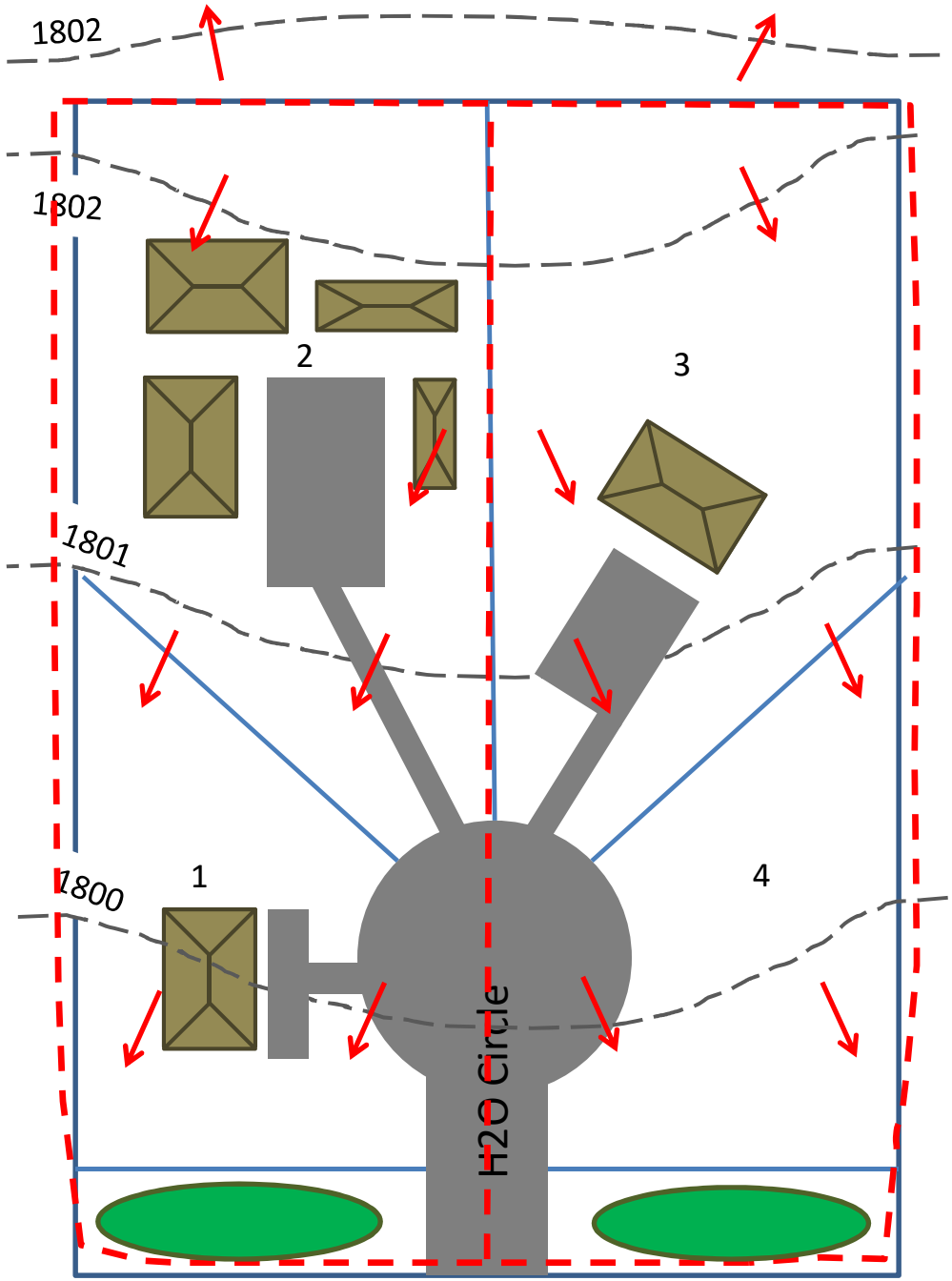
NEIGHBORHOOD SCALE



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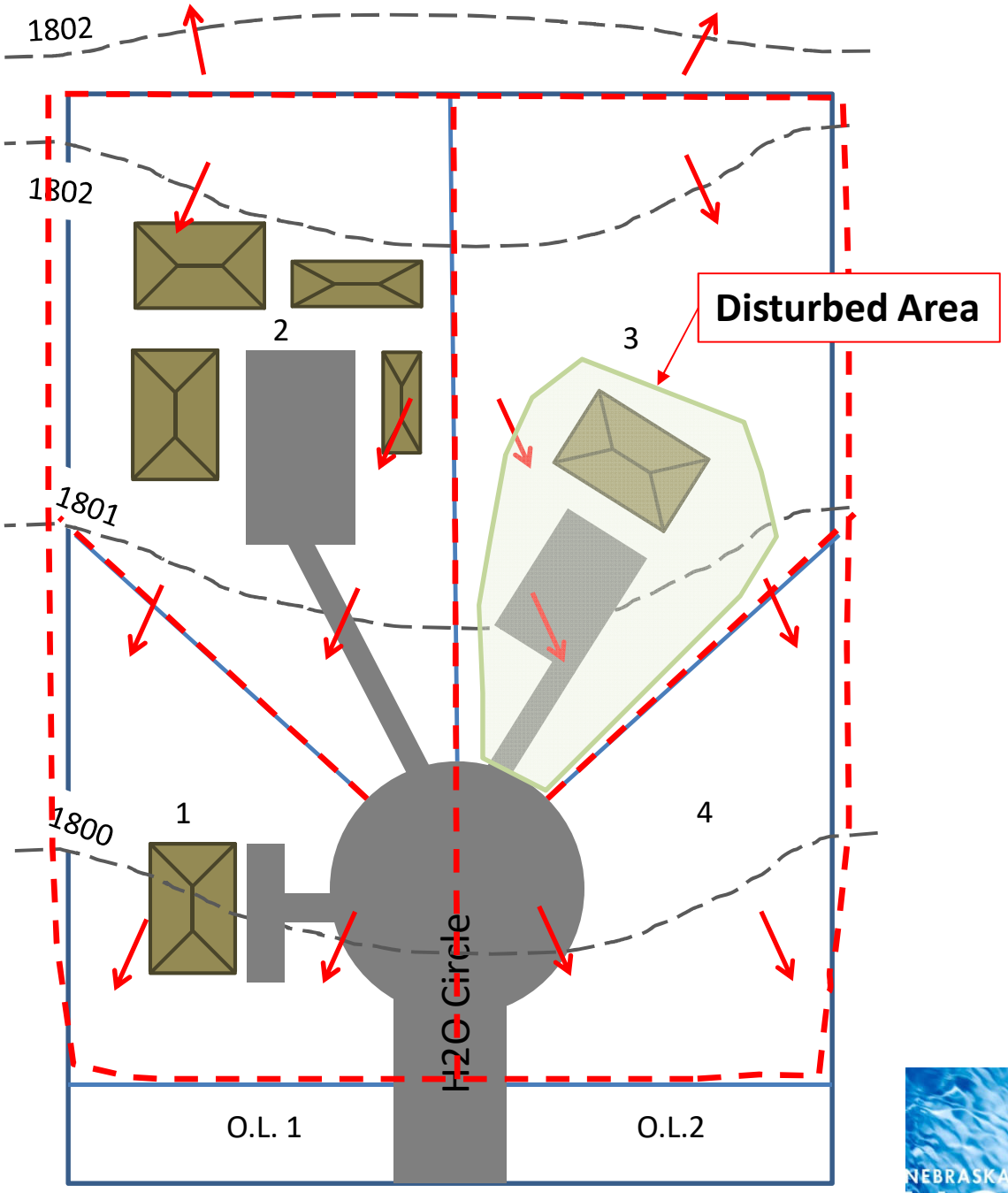
LOT SCALE



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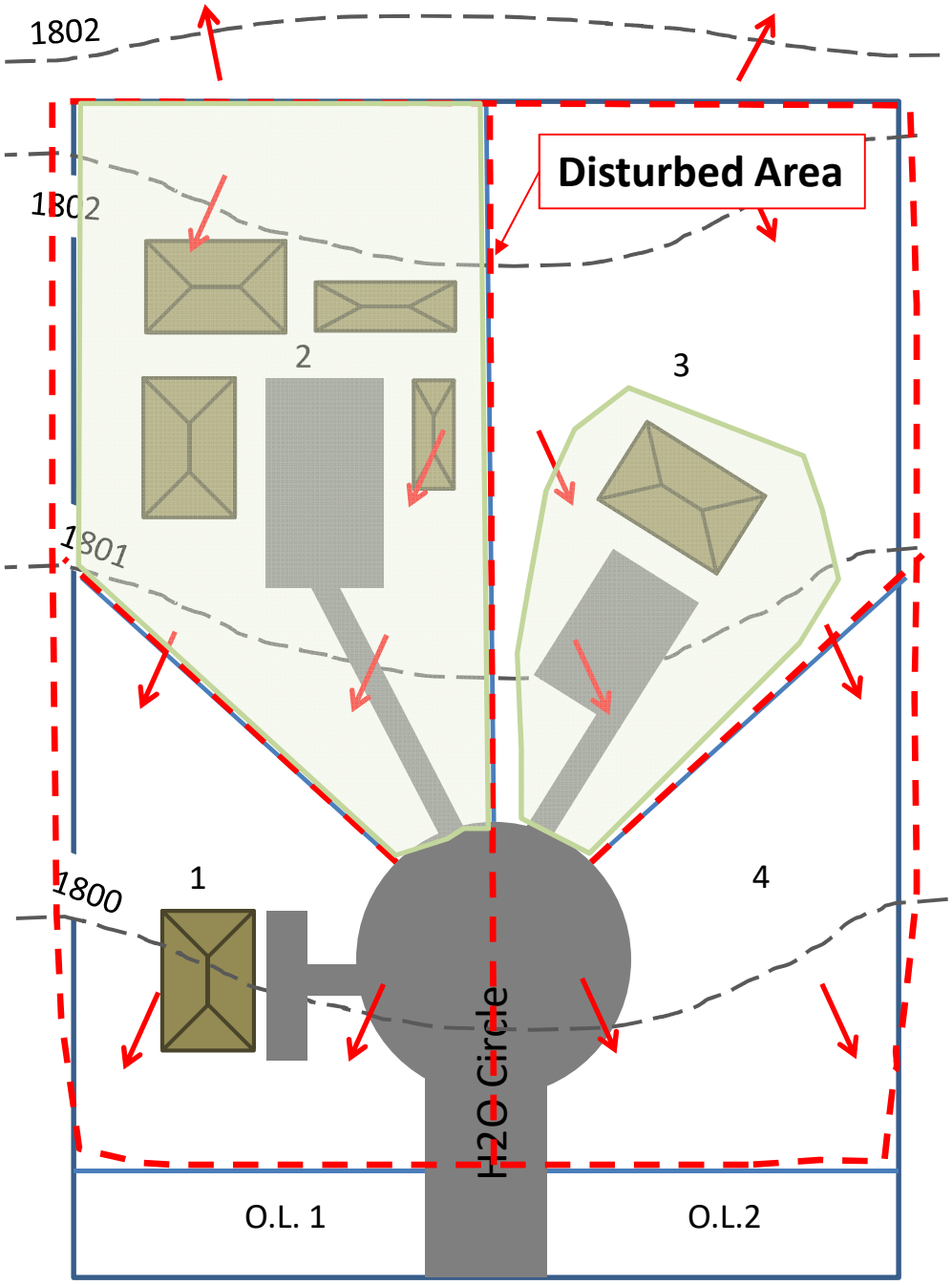

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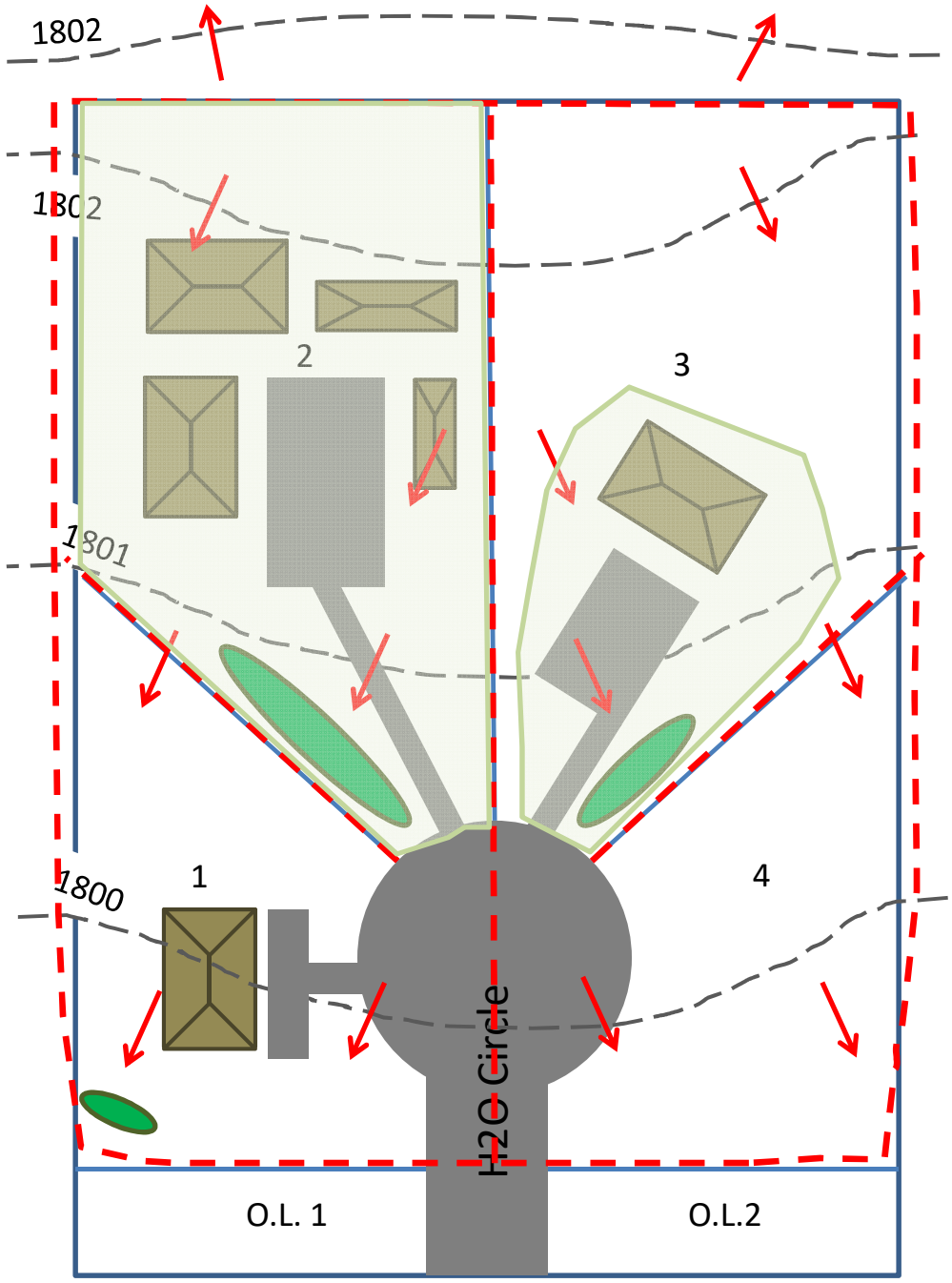

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Stormwater Management Integration

General

Runon

Storm Sewers and Drainageways

Major Storm Events

Detention

- Must account for all “runon”
- Must integrate with other stormwater management standards
- Must integrate with other stormwater management features

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Stormwater Management Integration

General

Runon

Storm Sewers and Drainageways

Major Storm Events

Detention

- "Runon" is the stormwater runoff generated upgradient from the site
- Accommodate all stormwater that gets to STF (don't overwhelm it)
- Can divert runon to bypass facility to reduce BMP size

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Stormwater Management Integration

General

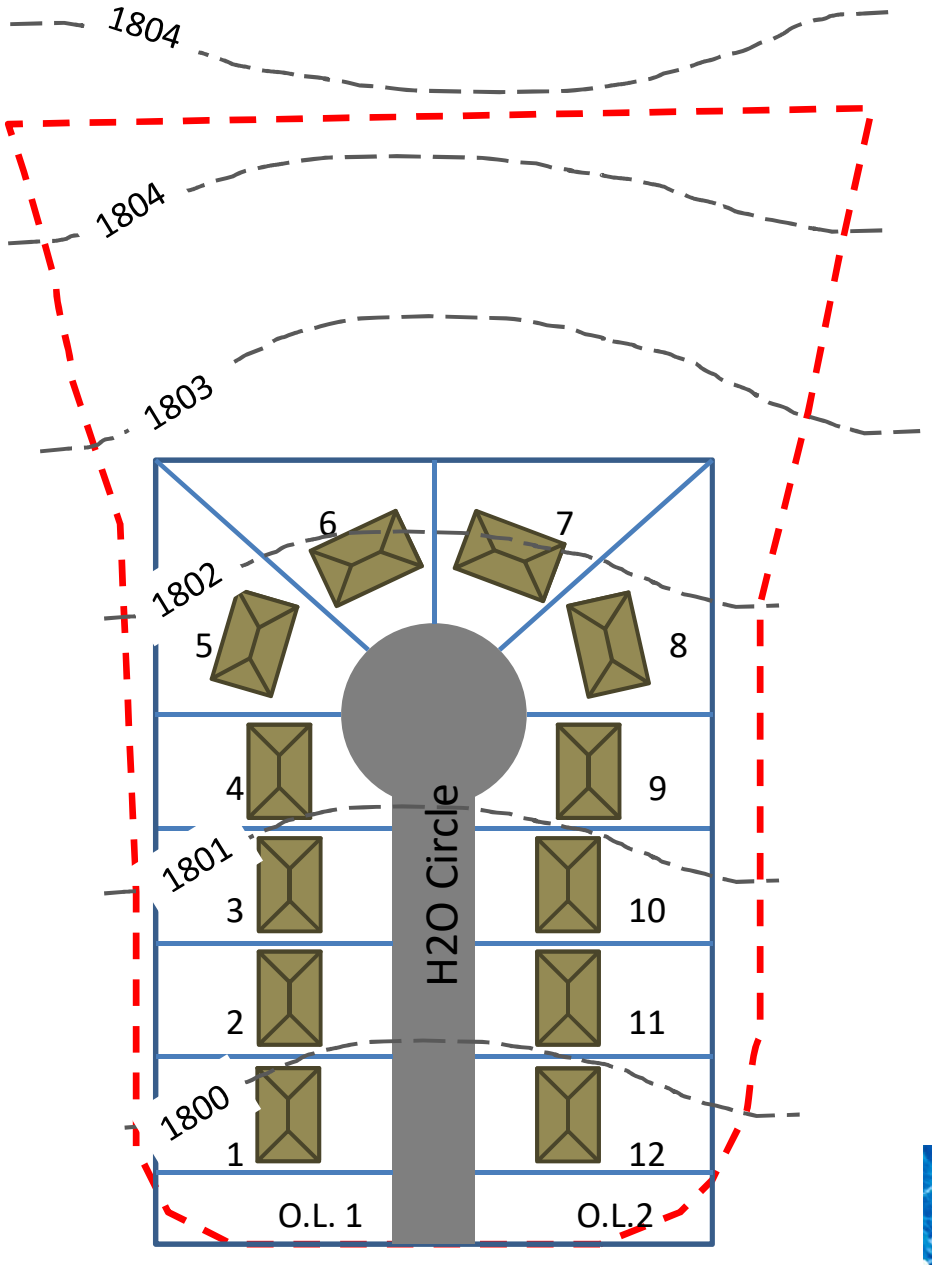
Runon - EXAMPLE

- **Option 1 - Treat all (4 ac + runon)**

Storm Sewers and Drainageways

Major Storm Events

Detention



Stormwater Management Integration

General

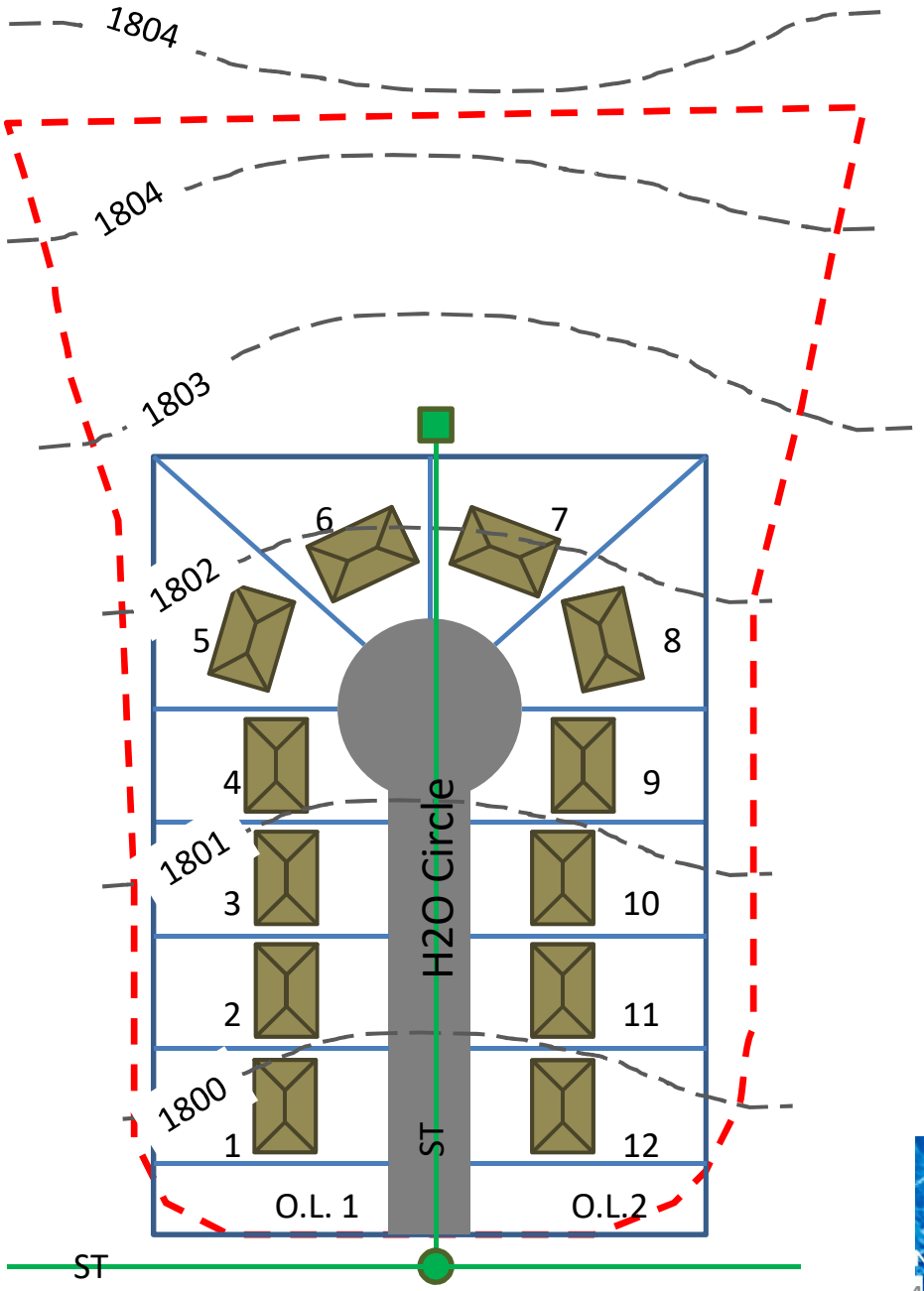
Runon - EXAMPLE

- **Option 1 - Treat all (4 ac + runon)**
- **Option 2 – Divert flow (i.e. pipe)**

Storm Sewers and Drainageways

Major Storm Events

Detention



Stormwater Management Integration

General

Runon

Storm Sewers and Drainageways

Major Storm Events

Detention

- Consider whether the BMP is online or offline
- Consider design standards for sewers, swales, and structures
  - i.e. 5- or 10-year storm sizing for sewers
- Consider major storms
  - i.e. 100-year flow paths

Stormwater Management Integration

General

Runon

Storm Sewers and Drainageways

Major Storm Events

Detention

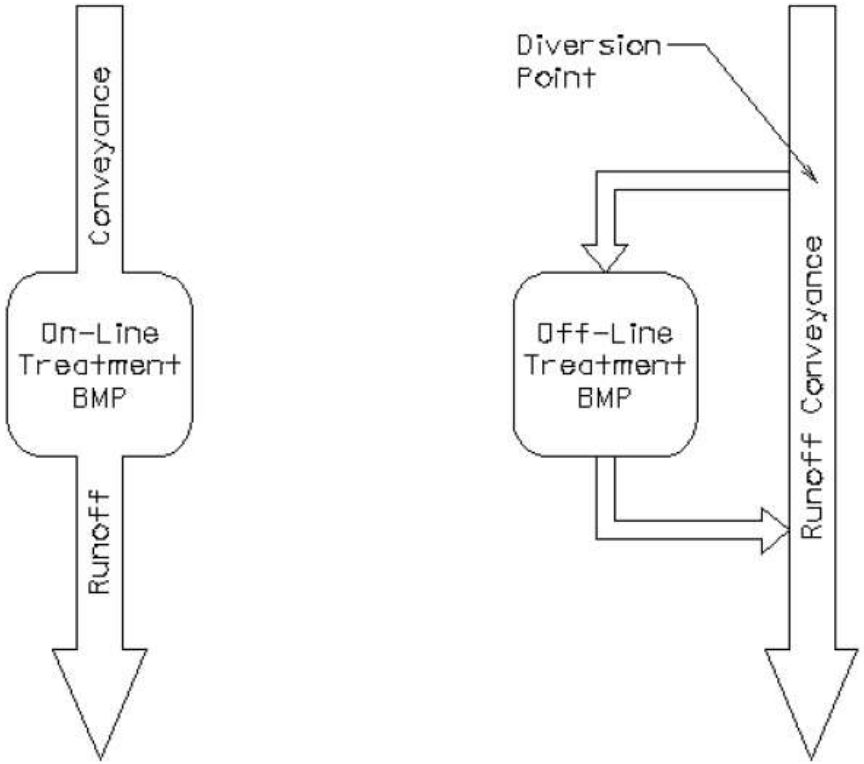


Exhibit 3.8 Schematic of Online and Offline Treatment BMPs

Stormwater Management Integration

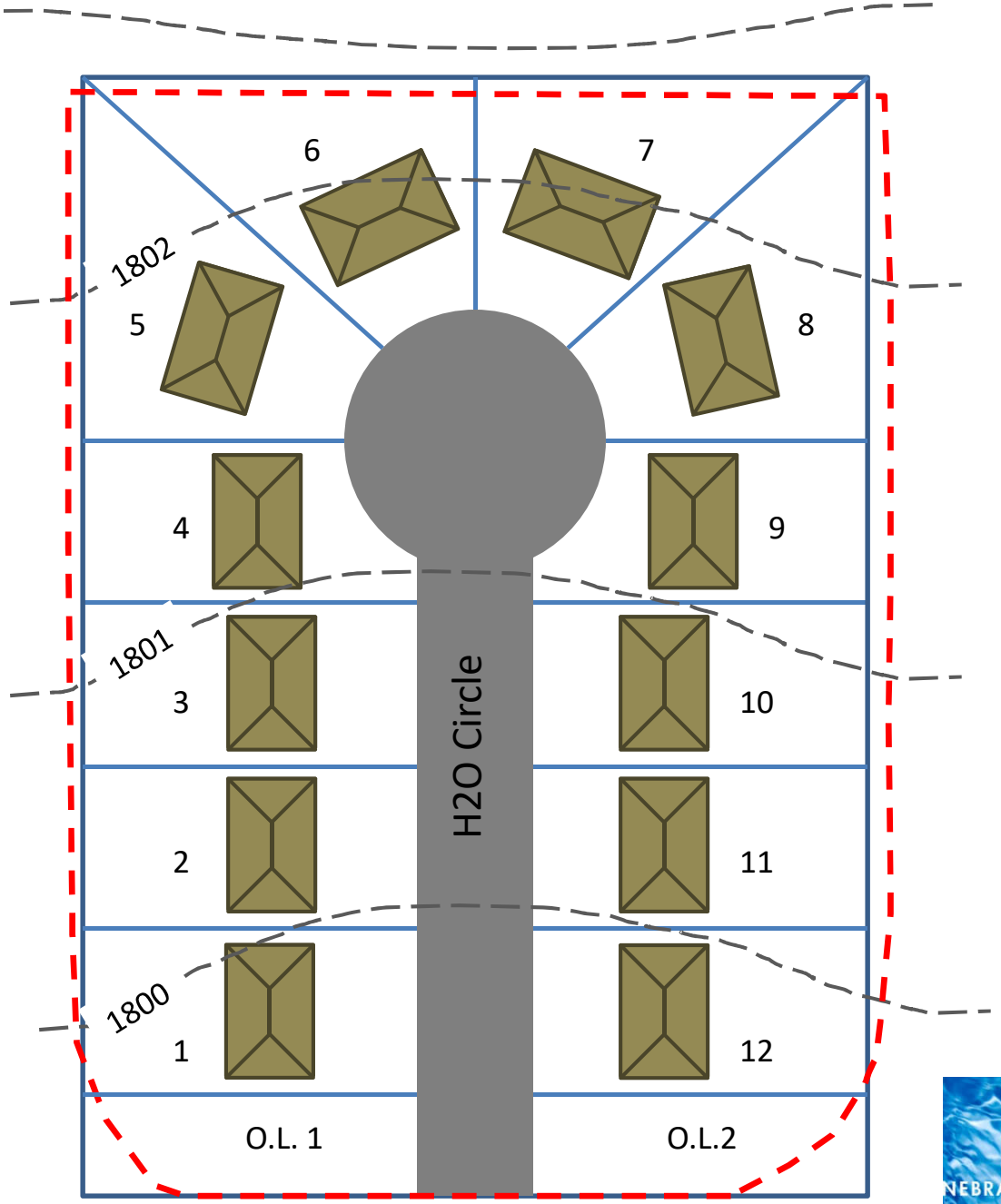
General

Runon

Storm Sewers and Drainageways

Major Storm Events

Detention



FELSBURG HOLT & ULLEVIG

Stormwater Management Integration

General

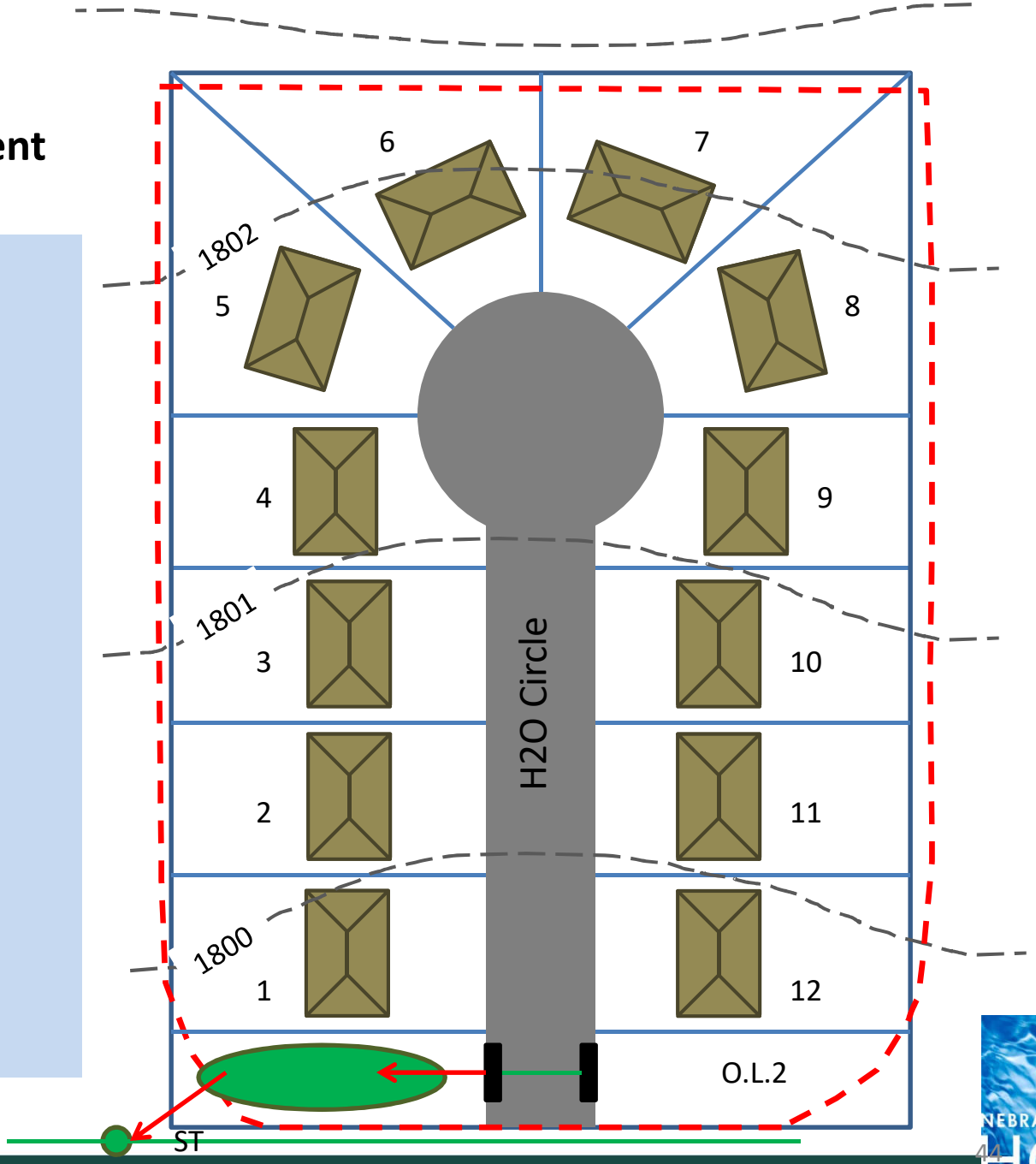
Runon

Storm Sewers and Drainageways

Major Storm Events

Detention

Online Treatment



Stormwater Management Integration

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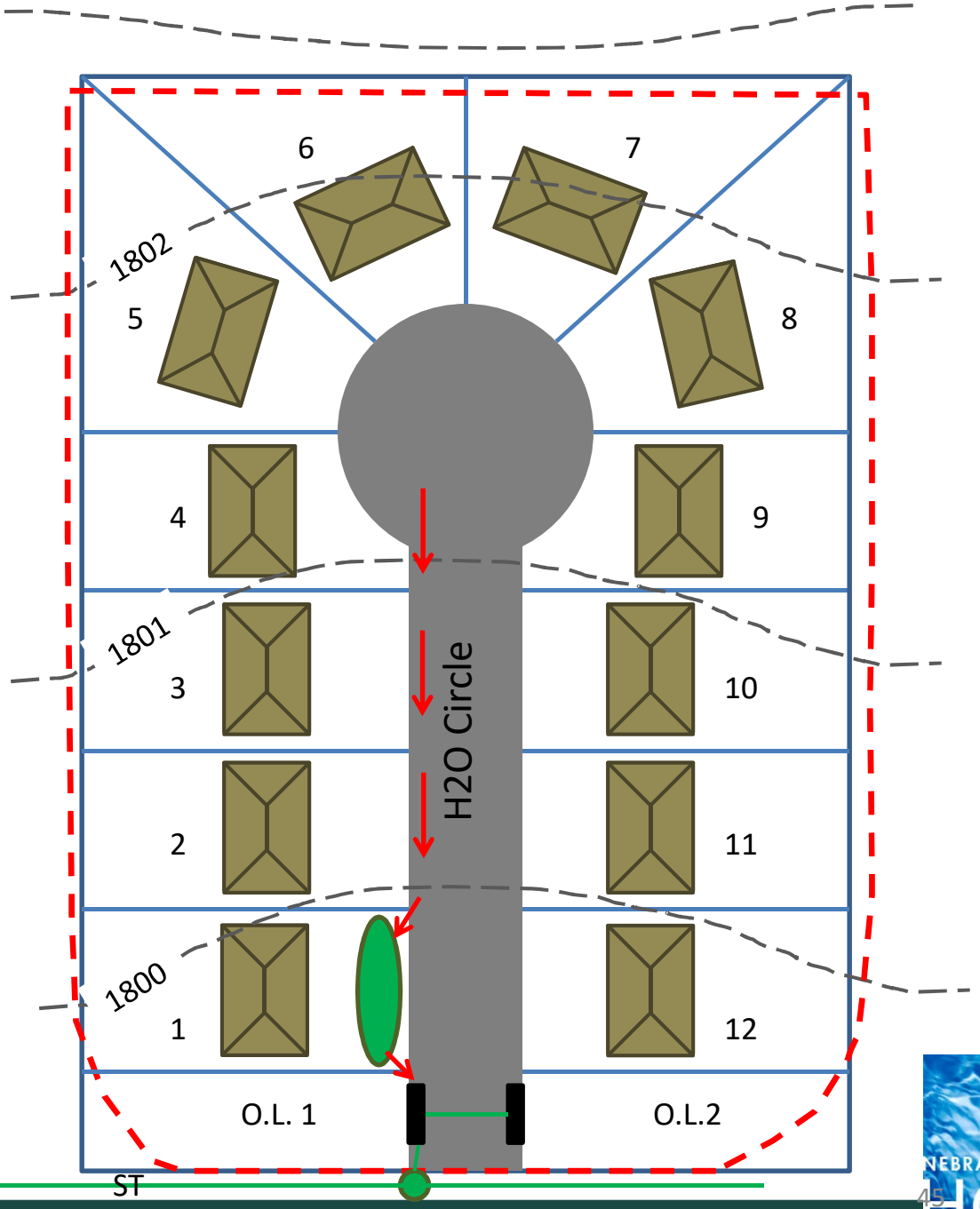
Offline Treatment



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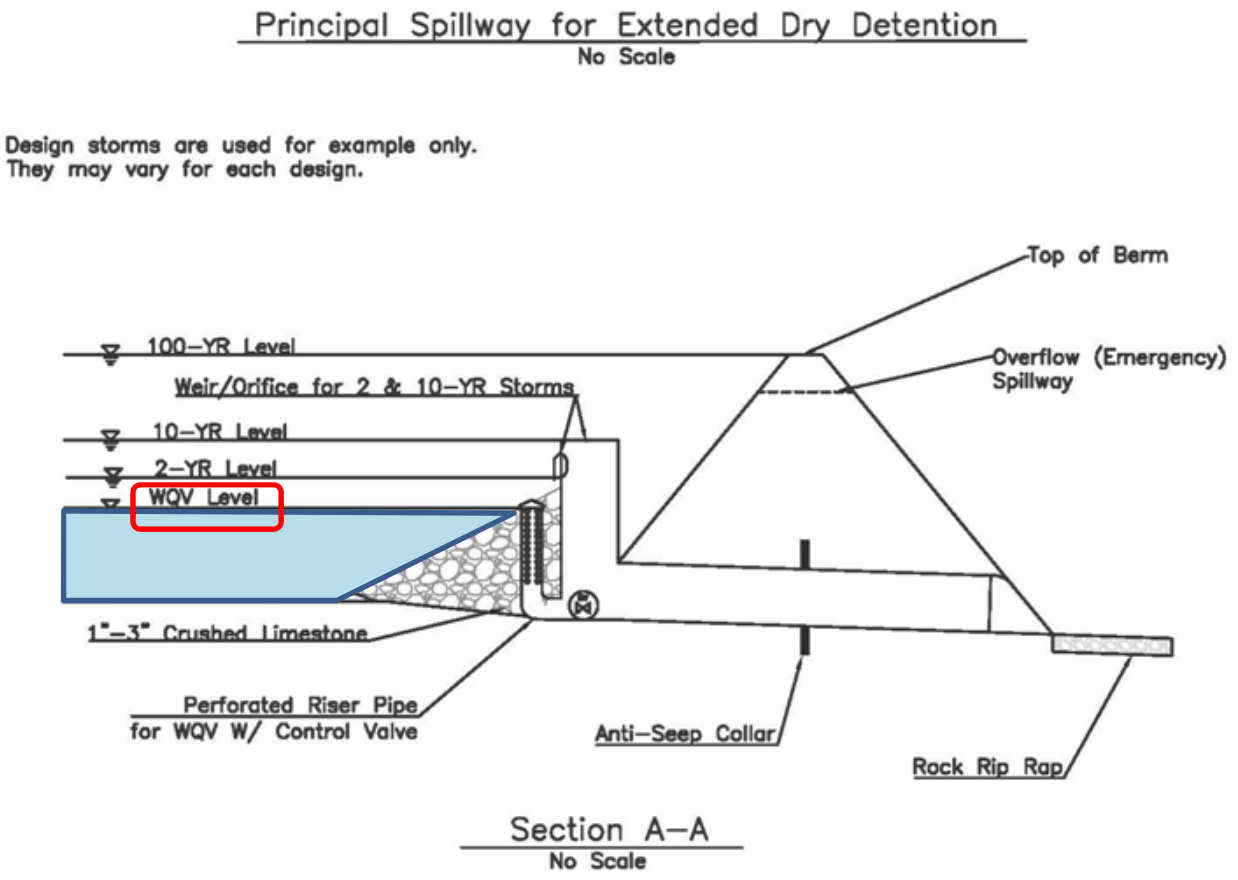
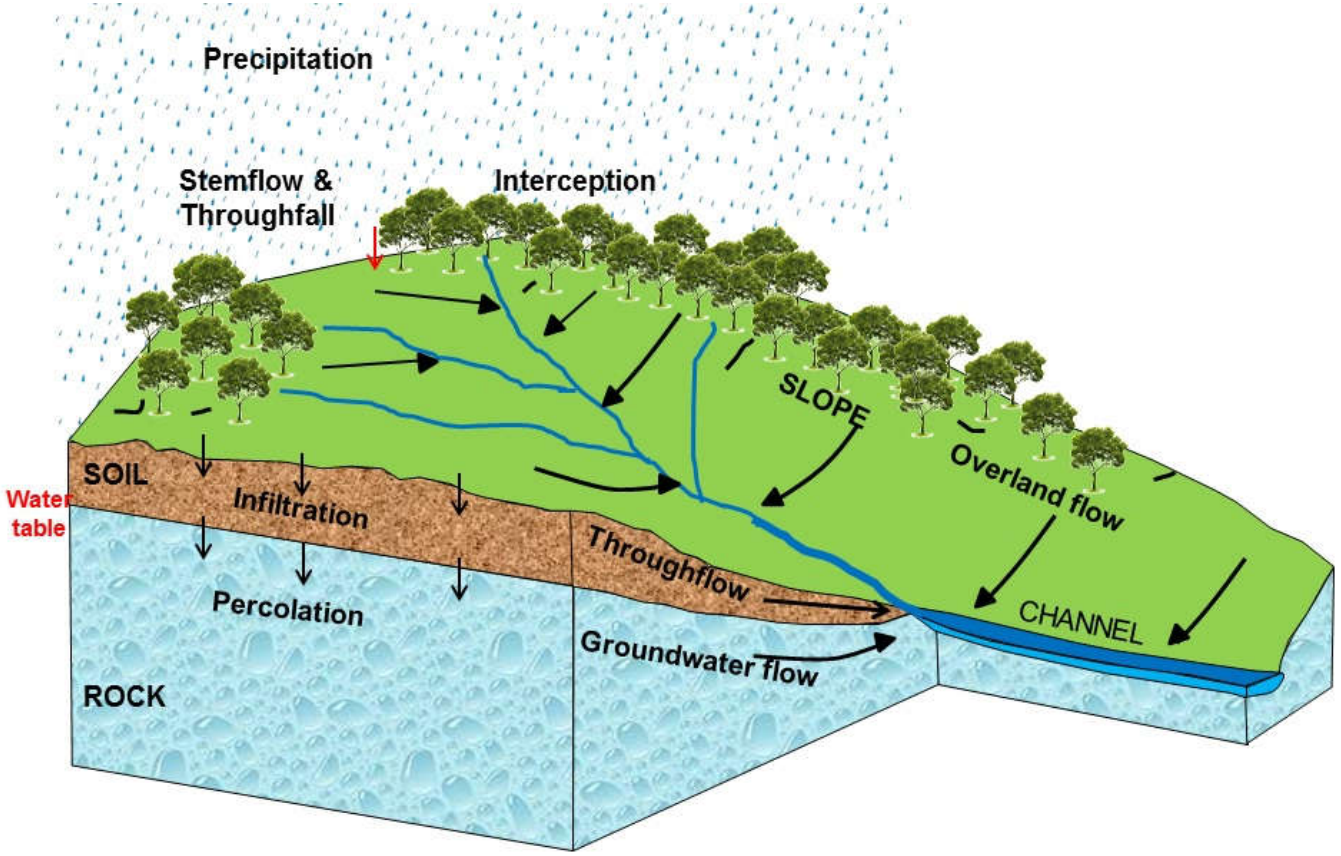


QUESTIONS?


Precipitation
Stemflow &
Throughfall
Interception
SLOPE
Overland flow
SOIL
Water
table
Infiltration
Throughflow
Percolation
CHANNEL
Groundwater flow
ROCK

Example of the WQCV equation:

A 4.2 acre parcel in Kearney was purchased to construct a storage facility. The parcel is one of 4 in a **new** development that was zoned limited industrial district (M-1). Light industrial zoning in Kearney has a maximum impervious percentage of **90**%. On that parcel, **2.4** acres will be disturbed to construct the facility. An additional 0.4 acres, also zoned M-1, drain directly onto the site from adjacent property. The WQCV for the site is calculated as follows:

WQCV=**0.72”**x(0.05+0.009x**90**) x (**2.4**ac)x 1/12 x 43,560= ***5,395 cubic feet.***

Design Example 2
Single Family Residential w/ Runon

General

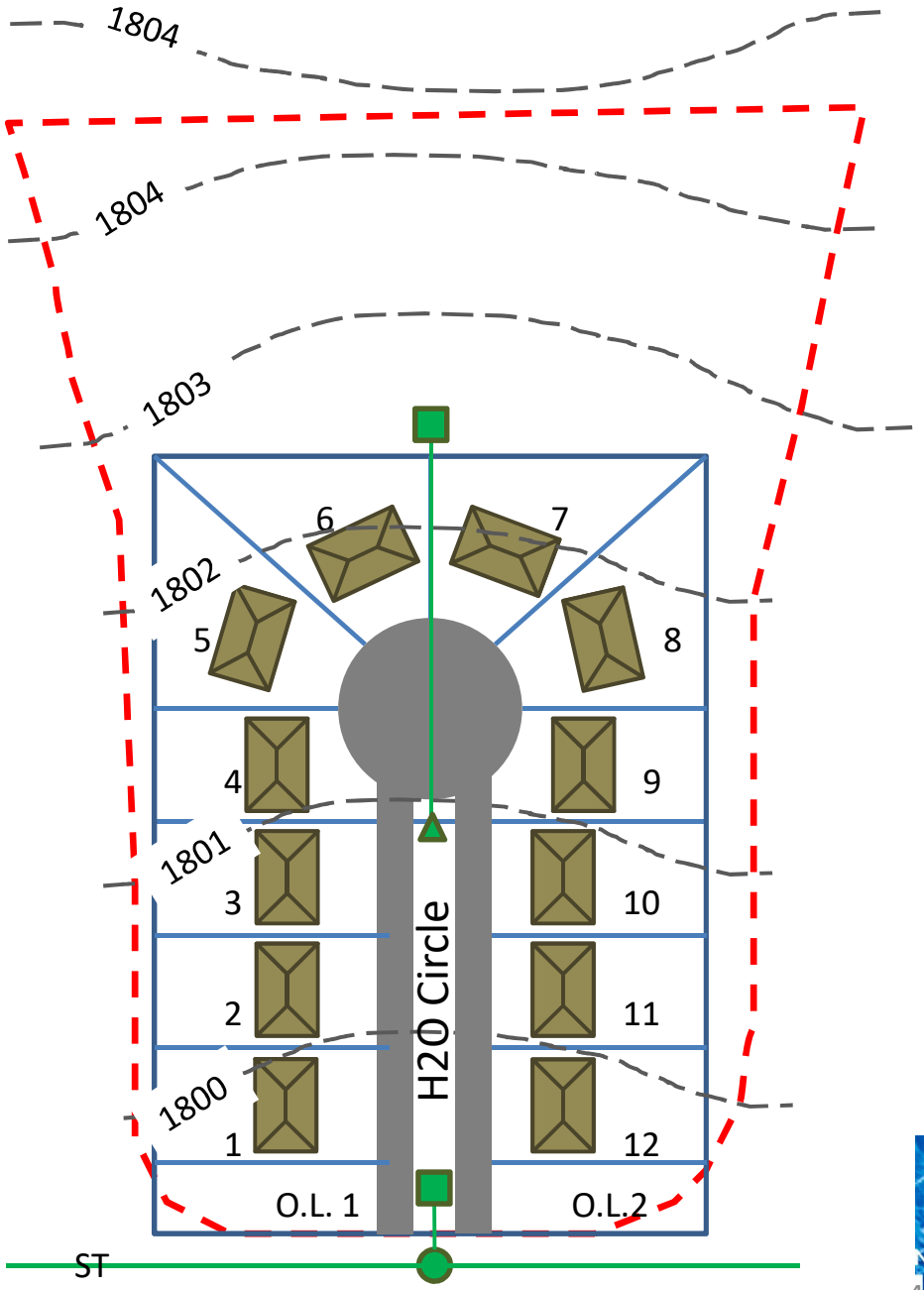
Runon - EXAMPLE

- **Option 1 - Treat all (4 ac + runon)**
- **Option 2 – Divert flow (i.e. pipe)**
- **Option 3 Comination**

Storm Sewers and Drainageways

Major Storm Events

Detention



Design Example 2
Single Family Residential

- Developer wants to build 12 single family residential lots on 4 acres in Kearney (Central Region)
- New Development
- Platted as medium-density (say R3)