

CITY OF CHARLOTTE  
DEPARTMENT OF TRANSPORTATION

# DETECTOR GUIDELINES

**Adopted July 2024**

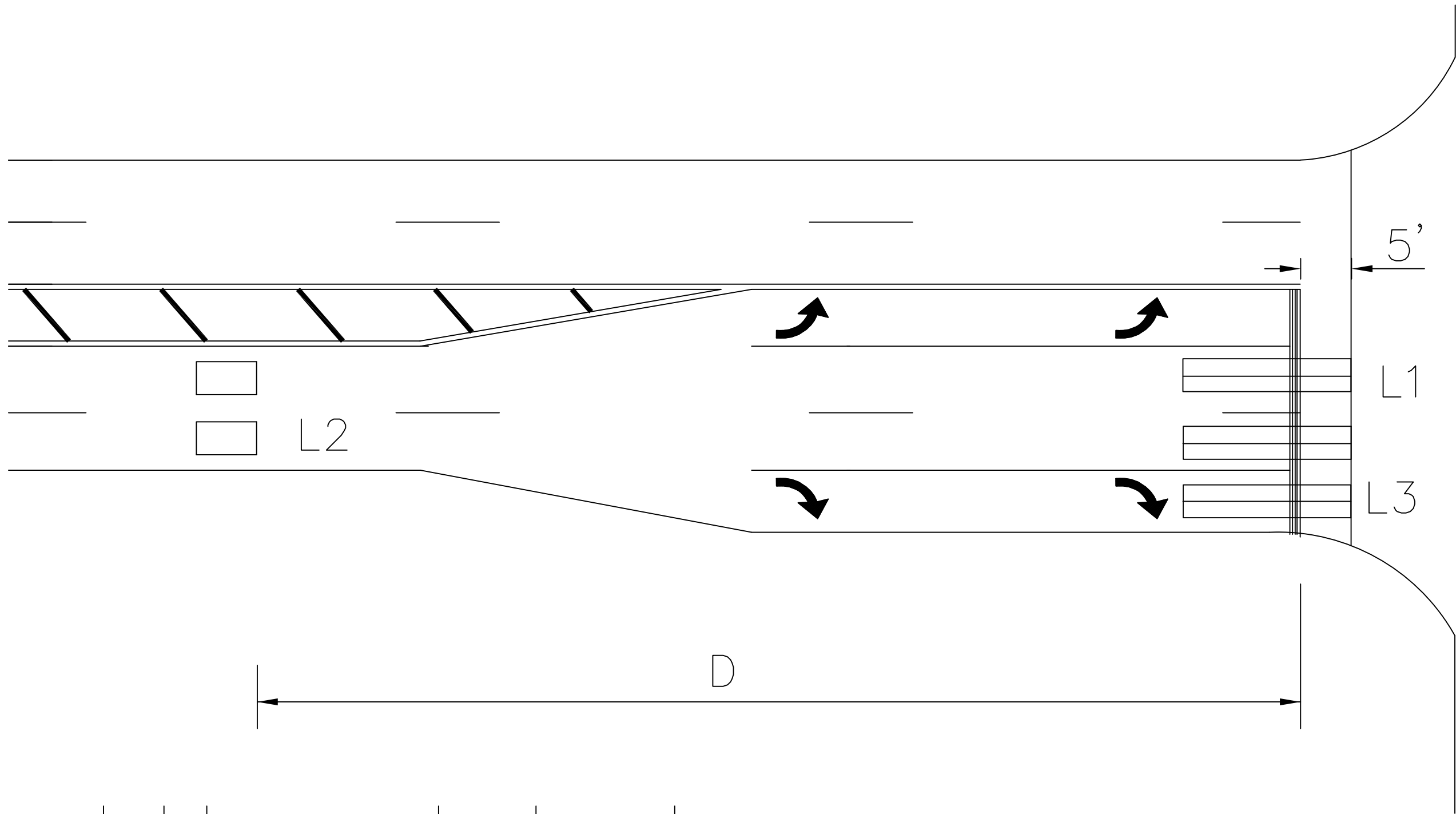
REVISED: Jonathan Dean

# GENERAL NOTES

1. Use loop detection as default with span wire configurations.
2. Use video detection as default with mast arm configurations.  
Ensure that video detection camera can see all zones being detected by the camera.  
\*Video/Thermal Detection in span wire applications is not approved by CDOT except in case-by-case situations when loops are not viable. Any proposed video/thermal detection on span wire assemblies shall have prior approval by CDOT Systems and Implementations Sections
3. Video detection camera placement
  - a. Mast arms— between left turn and thru
  - b. Span wire
    - i. One lane approach— far left or far right
    - ii. Multi-lane approach— far left AND far right
4. Refer to appendix for loop and splicing detail.

# LOOP DETECTION

# MAIN STREET



Note: All loops are connected to separate channels.

Detector: L1  
Size: 6’x25’ Quadrupole  
Connect to phase: Through  
Number of Turns: 2–4–2  
Amp Type: Normal  
Detector: L2  
Size: 6’x6’, one per lane  
Connect to Phase: Through  
Number of Turns: Based on lead–in;  
see appendix.  
Amp Type: Normal  
Detector: L3  
Size: 6’x25’ Quadrupole  
Connect to Phase: None (counting only)  
Number of Turns: 2–4–2  
Amp Type: Normal

SPEED (mph)	D (ft)	L2 Extend Time (sec)
25	120	2.9–Gap Time
30	155	3.7–Gap Time
35	200	4.1–Gap Time
40	250	4.5–Gap Time
45	300	4.8–Gap Time
50	355	5.1–Gap Time
55	420	5.5–Gap Time
60	475	5.7–Gap Time
65	550	6.1–Gap Time

NOTES:  
RECALL  
Main street in min or ped recall

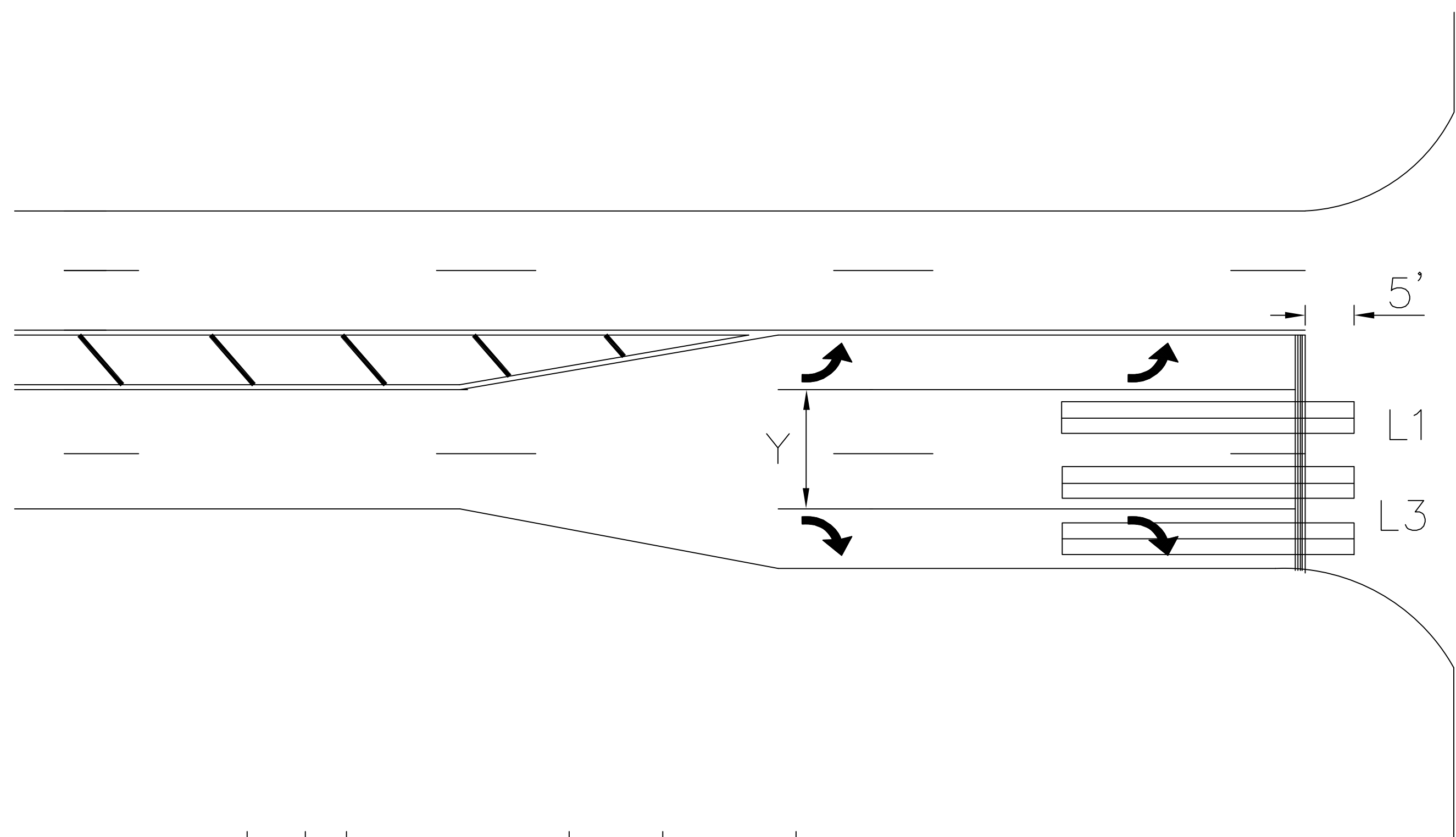
Systems to program L2 loops to extend in addition to gap time, If calculations results in a negative number, then no extend time in addition to gap time is applied. If loop placement is varied, Systems to recalculate extend times using the formula below.

Extend time (sec)= $\left(\frac{D-20'}{(Design\ speed-5)\ mph} \times \frac{3600\ sec/hr}{5280\ ft/mi}\right) - Gap\ time$

LEFT TURN LANE  
See separate sheet for left turn lane detection.  
RIGHT TURN LANE

Systems may elect to use right turn loop to call a phase where volumes are heavy. For stop bar loops, Systems may elect to use delay to address false calls from cross–street turning vehicles.

# SIDE STREET



Note: All loops are connected to separate channels.

Detector: L1  
Size: 6’x25’ Quadrupole  
Connect to phase: Through  
Number of Turns: 2–4–2  
Amp Type: Normal

Detector: L3  
Size: 6’x25’ Quadrupole  
Connect to Phase: Through or Concurrent Left on Main Street  
Number of Turns: 2–4–2  
Amp Type: Delay

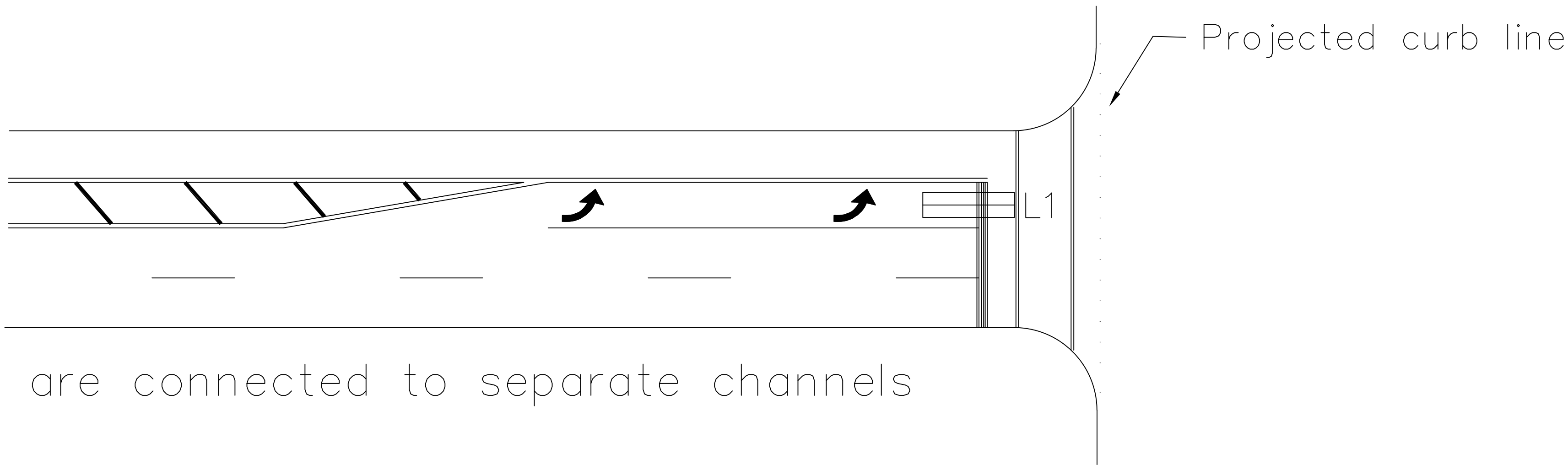
NOTES:  
LEFT TURN LANE  
See separate sheet for left turn lane detection

RIGHT TURN LANE  
If the main street has protected only left turn phases or FYAs in both directions. L3 will connect to the main street left turn phase. The delay is disabled during the main street left turn phase. Typically use 10 seconds of delay except where right turns on red are prohibited. Systems may elect to adjust or remove delay.

THRU LANE  
Systems may elect to add advance loops. If used, these loops shall be designed following the same guidelines as "L2" Main Street loops.

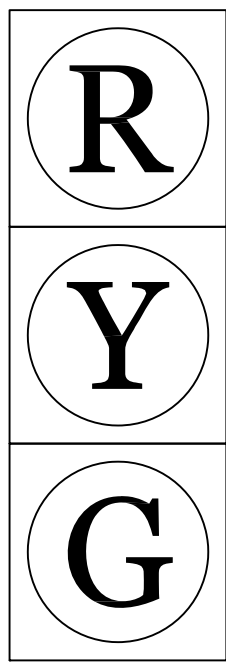
For stop bar loops, Systems may elect to use a 3-second delay to address false calls from cross-street turning vehicles.  
Systems may elect to add up to a 5-second delay if through lane is shared with right turns, except where right turns on red are prohibited.

# LEFT TURN LANES



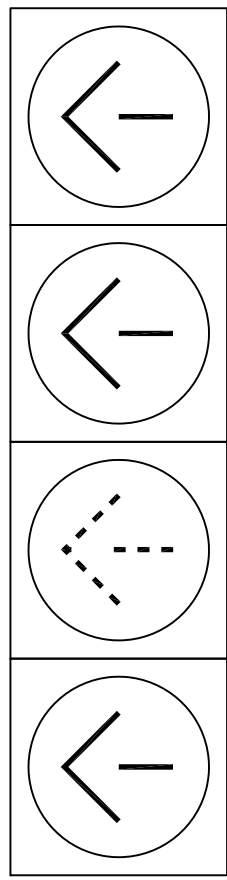
Note: All loops are connected to separate channels

## NO LEFT TURN PHASE



Detector: L1  
Size: 6'x25' Quadrapole  
Connect to Phase: Through  
Number of Turns: 2-4-2  
Amp Type: Normal

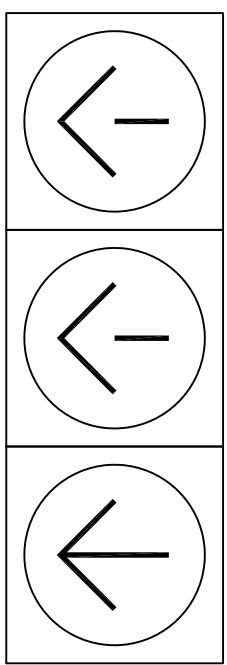
## PROTECTED/PERMITTED LEFT TURN PHASE



Detector: L1  
Size: 6'x25' Quadrapole  
Connect to Phase: Left turn AND opposing through  
Number of Turns: 2-4-2  
Amp Type: Normal

NOTE: Systems may elect to add a delay for L1.  
For phases connection, systems may elect to replace opposing through with either adjacent through, cross-switching, or calling left turn only.

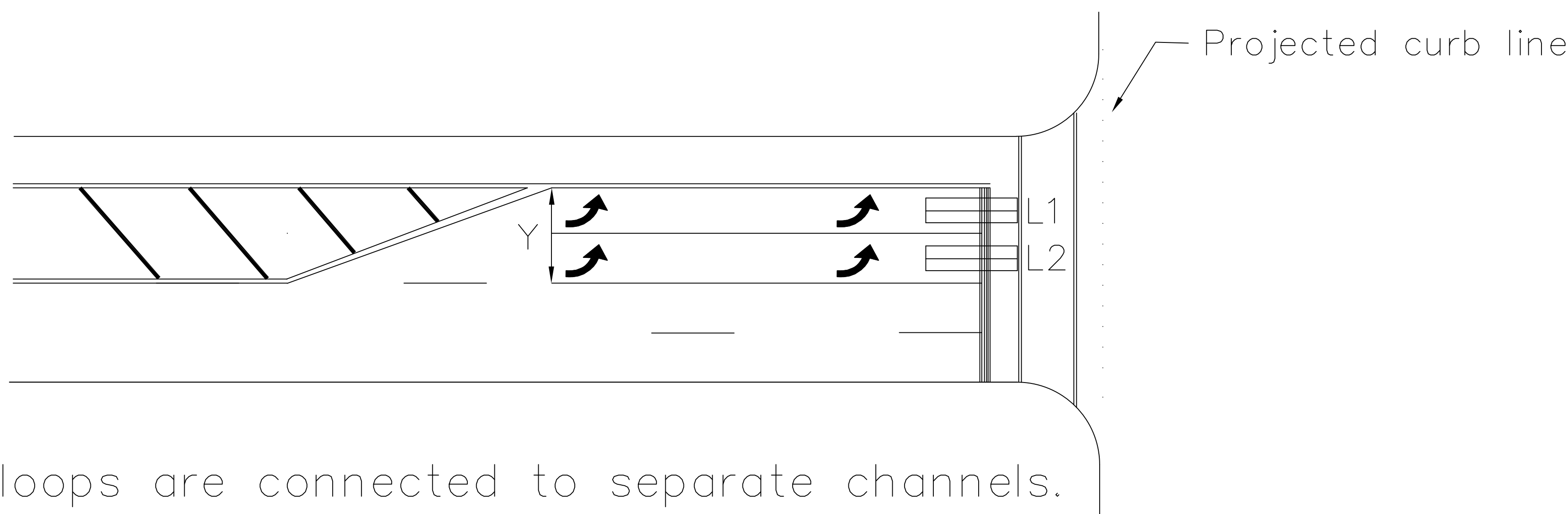
## PROTECTED ONLY LEFT TURN PHASE



Detector: L1  
Size: 6'x25' Quadrapole  
Connect to Phase: Left Turn  
Number of Turns: 2-4-2  
Amp Type: Normal

NOTE: Regardless of left turn phasing, Systems may elect to use a short delay to address false calls from cross-street turning vehicles.

# DUAL LEFT-TURN LANES



NOTE: All loops are connected to separate channels.

Detector: L1, L2

Size: 6'x25' Quadrupole

Connect to Phase: Left turn

Number of Turns: 2-4-2

Amp Type: Normal

Note: For stop bar loops, Systems may elect to use a short delay to address false calls from cross-street turning vehicles.

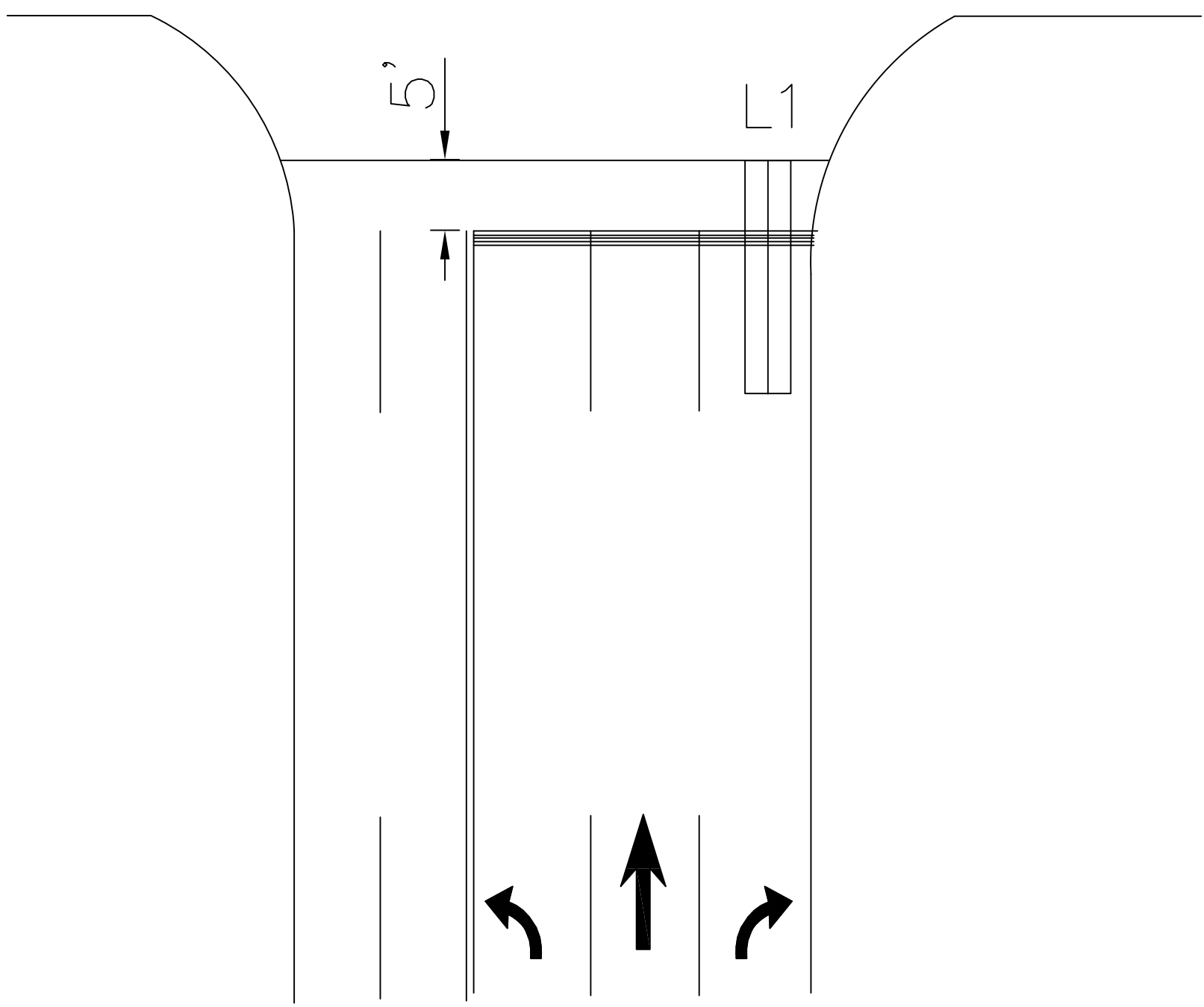
# RIGHT TURN DETECTOR LAYOUTS

- L1 = 6ft x 25ft Quadrupole loop
- L2 = 6ft x 6ft (Minimum) Presence loop  
Wired to separate detector/ channel
- L3 = 6ft x 25ft Quadrupole loop

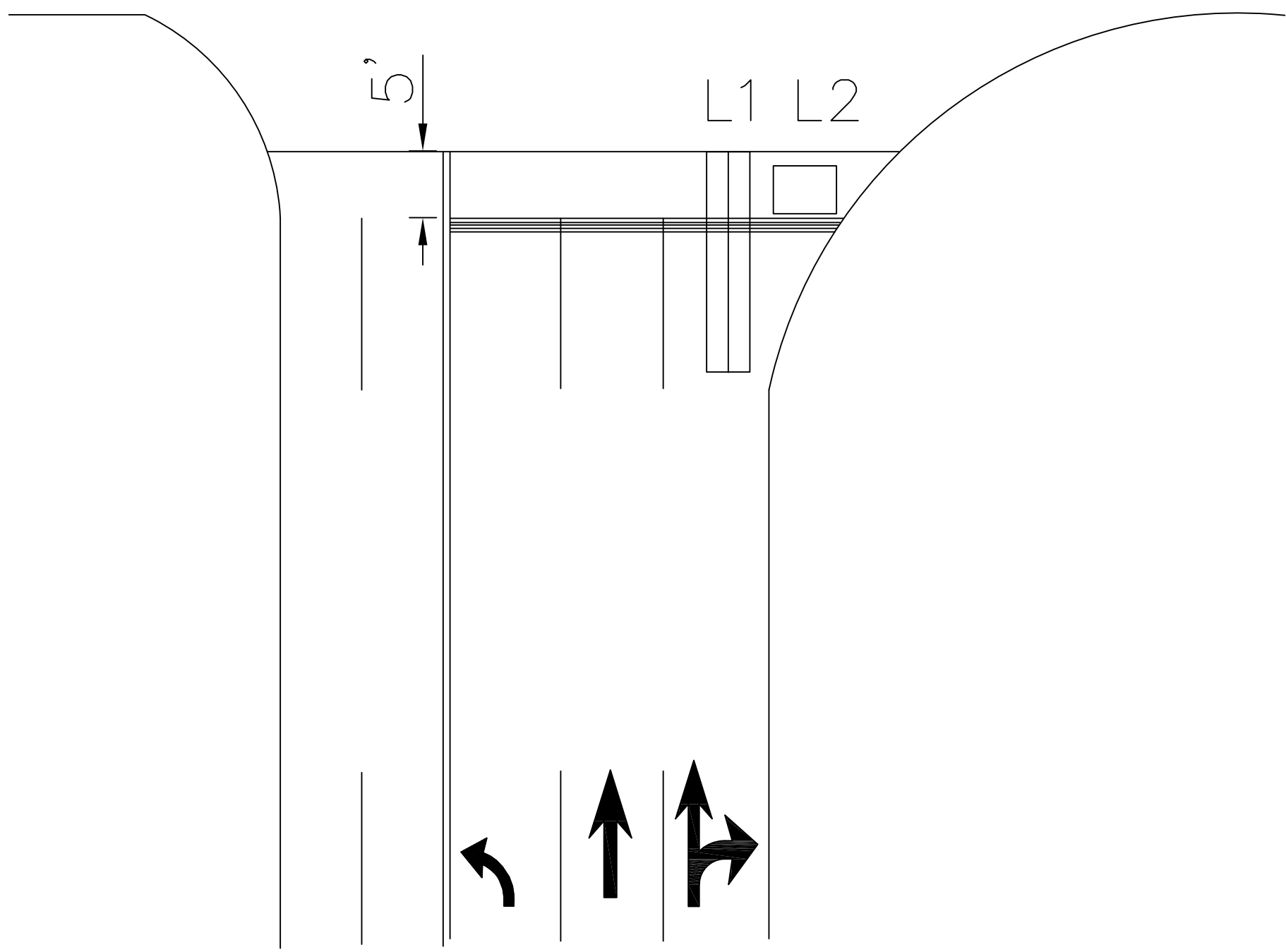
## NOTES:

—Call delay appropriate for right turn loops unless right turn on red is prohibited. Suggested delay: 10sec

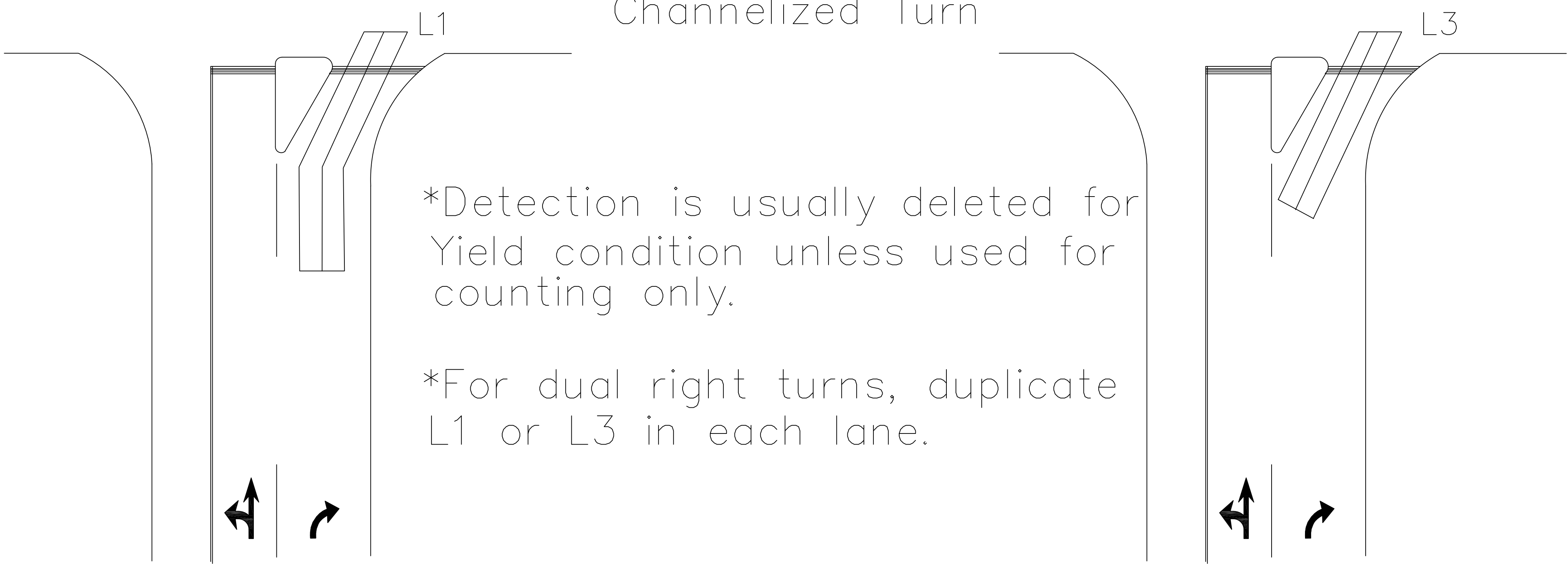
Standard Turn



Wide Radius Turn



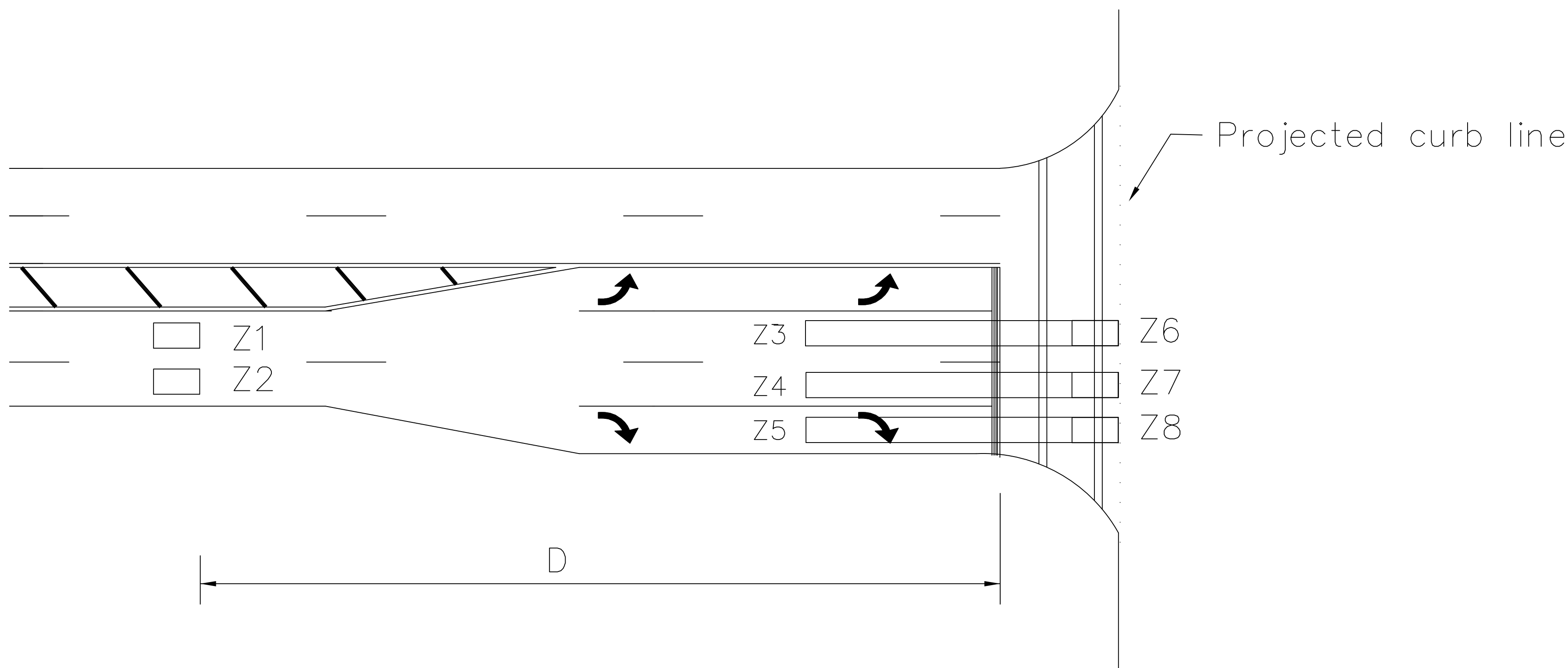
Channelized Turn





# VIDEO/THERMAL DETECTION

# MAIN STREET



Note: All zones are connected to separate channels.  
ADVANCE

Detector zones: Z1,Z2  
Connect to phase: Through  
Amp type: Normal  
Zone size: 6’x6’

STOP BAR

Detector zones: Z3,Z4  
Connect to phase: Through  
Amp type: Normal  
Limits: 80’ from stop bar  
Extend zones beyond stop bar to projected curb line

RIGHT TURN STOP BAR

Detector zone: Z5  
Connect to phase: None (counting only)  
Amp type: Normal  
Limits: 80’ from stop bar  
Extend zone beyond stop bar to projected curb line

COUNT ZONES

Detector zone: Z6–Z8  
Connect to phase: None (counting only)  
Amp type: Normal  
Zone size: 6’x6’

Systems may elect to use Z5 to call a phase where right turn volumes are heavy.  
Main street in min or ped recall.

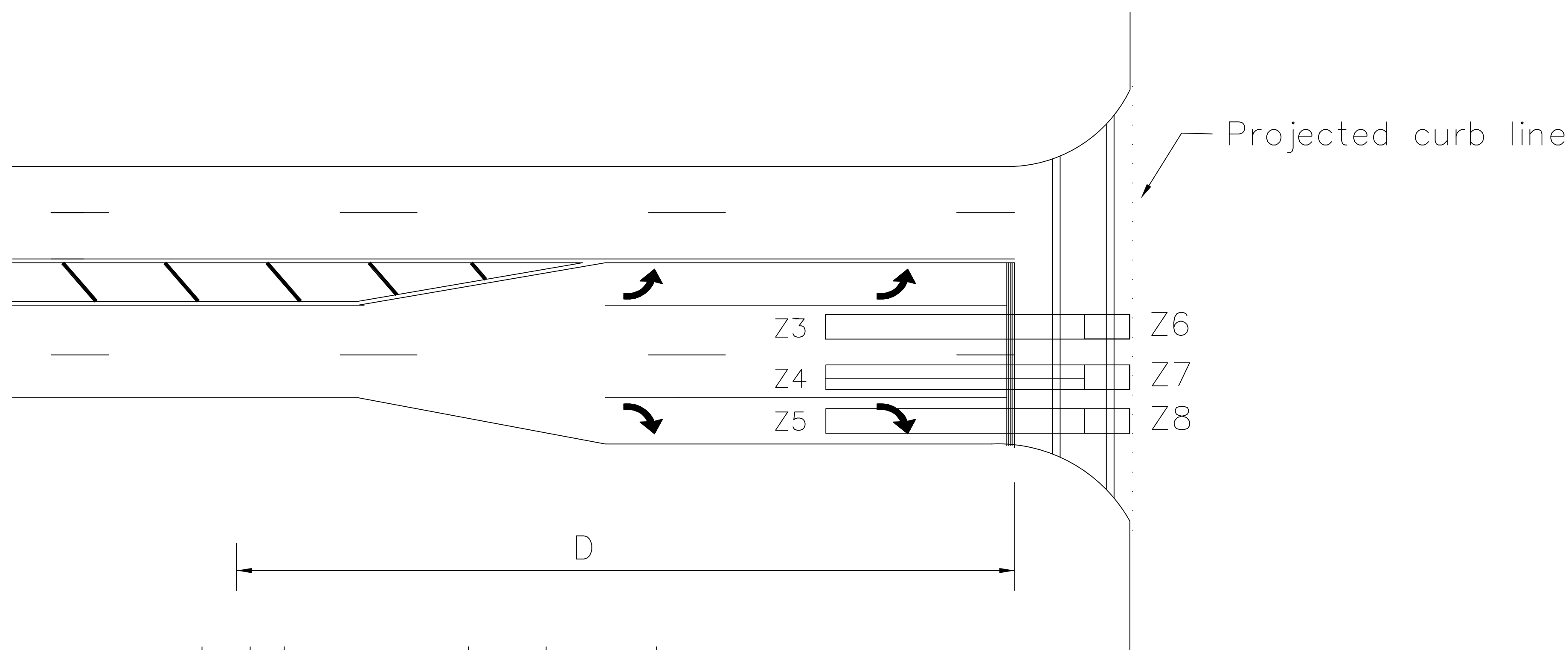
LEFT TURN LANE

See separate sheet for left turn lane detection.

SPEED (mph)	D (ft)	z Extend Time (sec)
25	120	2.9–Gap Time
30	155	3.7–Gap Time
35	200	4.1–Gap Time
40	250	4.5–Gap Time
45	300	4.8–Gap Time
50	355	5.1–Gap Time
55	420	5.5–Gap Time
60	475	5.7–Gap Time
65	550	6.1–Gap Time

\*See page 2 for formula

# SIDE STREET



All zones are connected to separate channels.  
Systems may elect to add advance zones. These zones will follow Z1, Z2 main street guidelines.

STOP BAR  
Detector zones: Z3,Z4  
Connect to phase: Through  
Amp type: Normal  
Limits: 80’ from stop bar  
Extend zones beyond stop bar to projected curb line

RIGHT TURN STOP BAR  
Detector area: Z5  
Limits: 80’ from stop bar  
extend zones beyond stop bar to projected curb line  
Connect to phase: Through  
Amp type: Delay

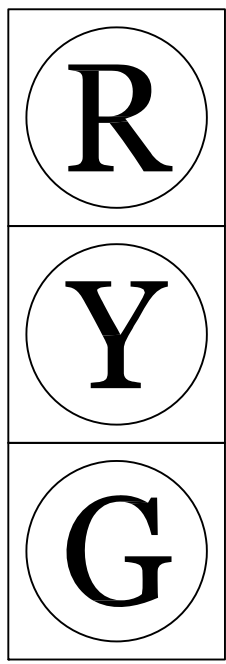
COUNT ZONES  
Detector zone: Z6–Z8  
Connect to phase: None (counting only)  
Amp type: Normal  
Zone size: 6’x6’

LEFT TURN LANE  
See separate sheet for left turn lane detection.

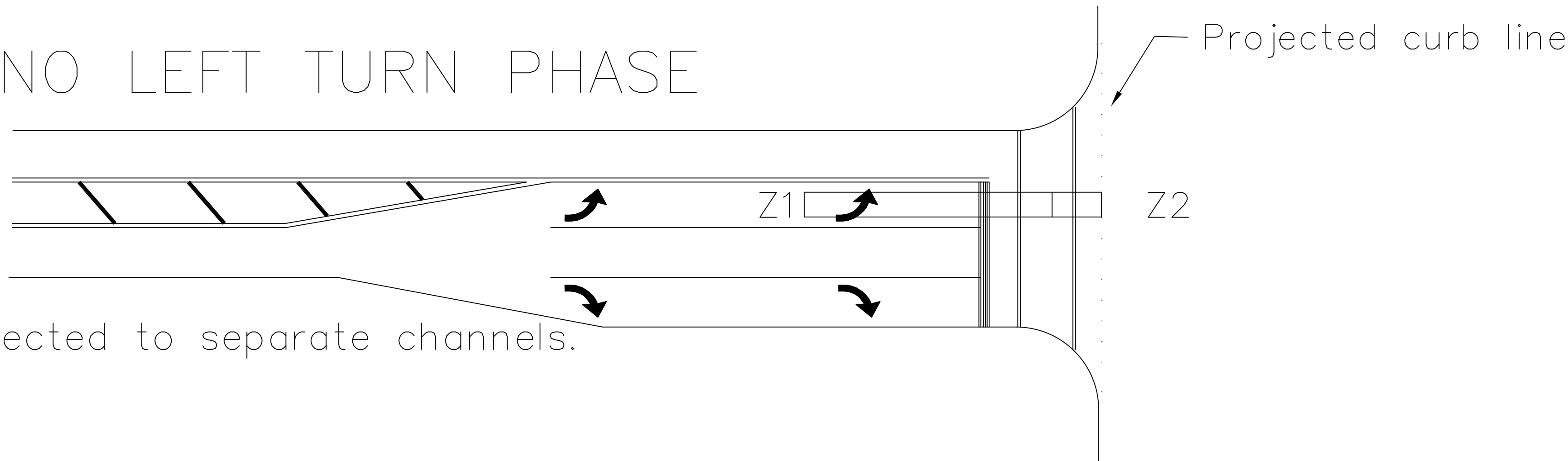
RIGHT TURN LANES  
If the main street has protected only left turn phases or FYA’s in both directions, Z5 will connect to the main street left turn phase. Typically use 10 seconds of delay except where right turns on red are prohibited. The delay is disabled during the phase called. Systems may elect to adjust or remove delay.

Systems may elect to add a short delay if the through lane is shared with right turns, except where right turns on red are prohibited.

# LEFT TURN LANES



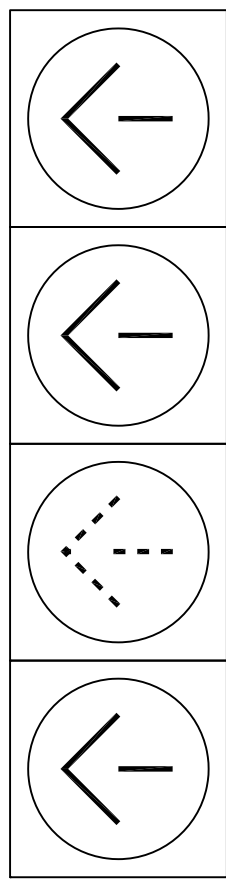
## NO LEFT TURN PHASE



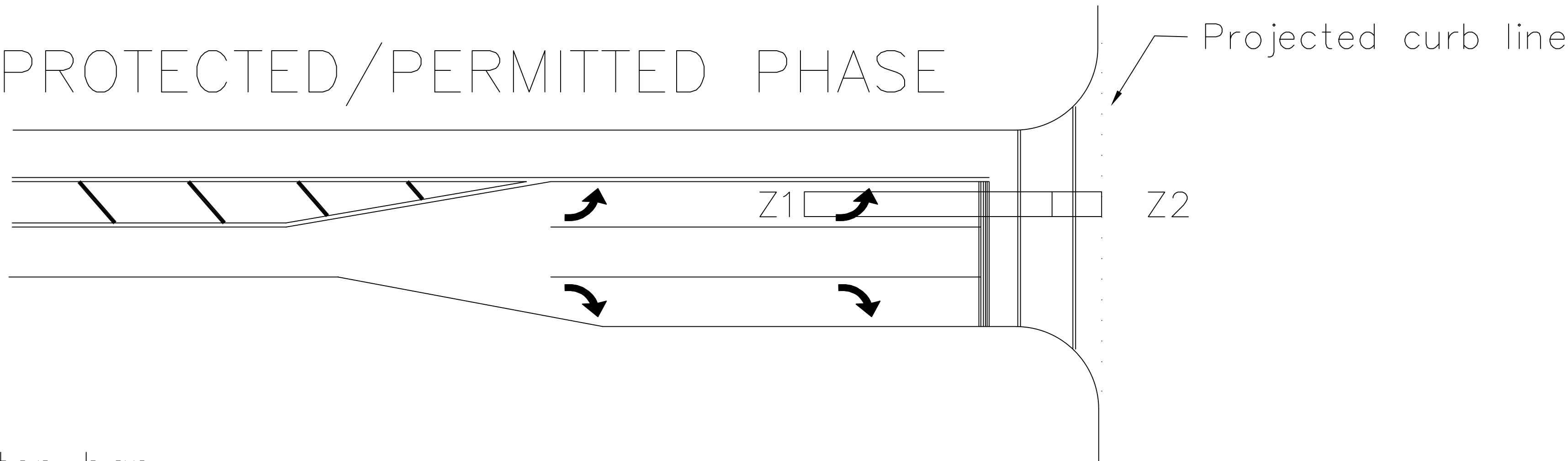
All zones are connected to separate channels.

Detector area: Z1  
Limits: 80' from stop bar  
extend zone beyond stop bar to projected curb line  
Connect to phase: Through  
Amp type: Normal

Detector area: Z2  
Zone size: 6'x6'  
Connect to phase: None (Counting only)  
Amp type: Normal



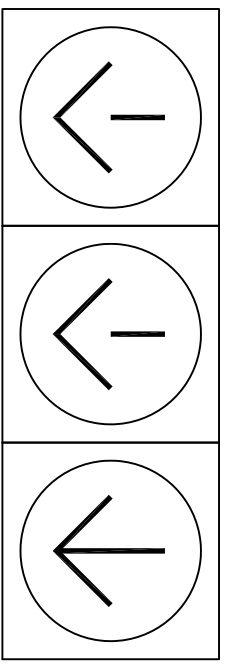
## PROTECTED/PERMITTED PHASE



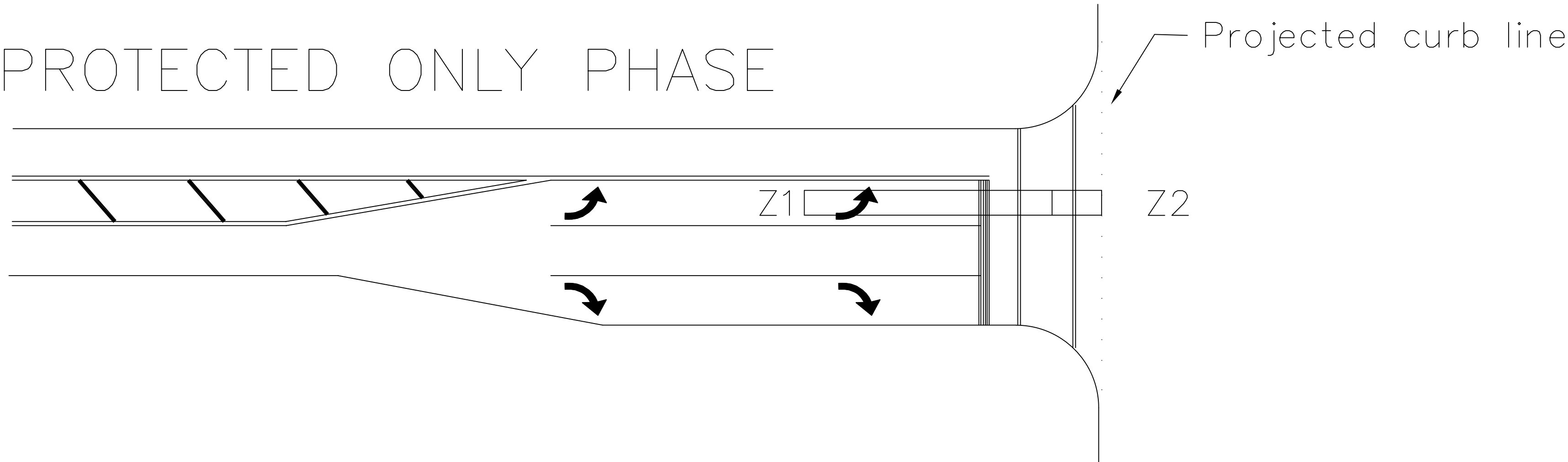
Detector area: Z1  
Limits: 80' from stop bar  
extend zone beyond stop bar to projected curb line  
Connect to phase: Left turn AND opposing through  
Amp type: Normal

Detector area: Z2  
Zone size: 6'x6'  
Connect to phase: None (Counting Only)  
Amp type: Normal

Note: For Z1, Systems may elect to replace opposing through with either adjacent through, cross-switching, or calling left turn only. Systems may elect to add delay to Z1.



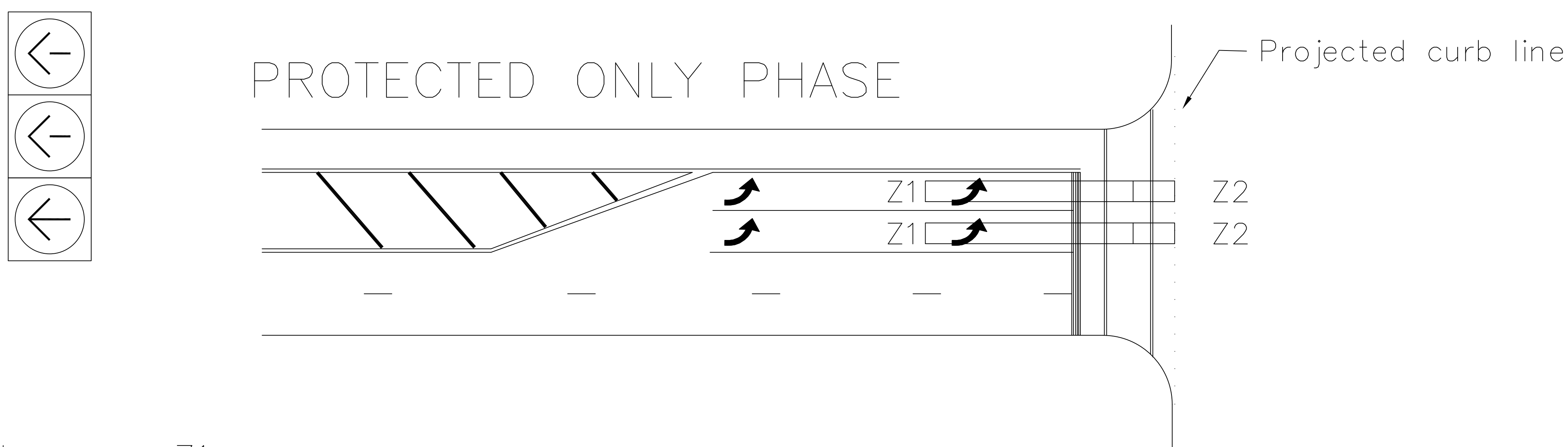
## PROTECTED ONLY PHASE



Detector area: Z1  
Limits: 80' from stop bar  
extend zone beyond stop bar to projected curb line  
Connect to phase: Left turn  
Amp type: Normal

Detector area: Z2  
Zone size: 6'x6'  
Connect to phase: None (Counting Only)  
Amp type: Normal

# DUAL LEFT-TURN LANES

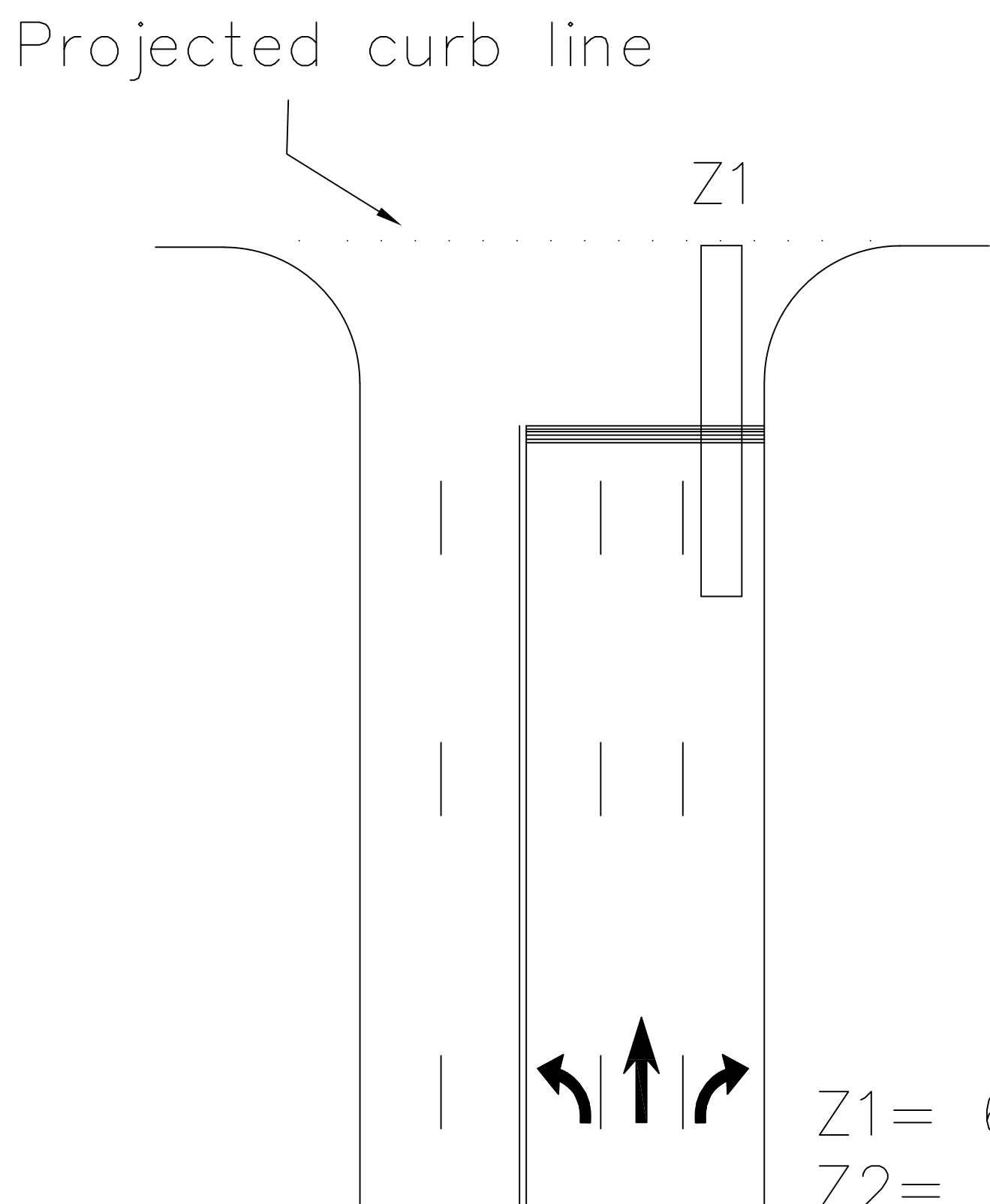


Detector area: Z1  
Limits: 80' from stop bar  
    extend zone beyond stop bar to projected curb line  
Connect to phase: Left turn  
Amp type: Normal

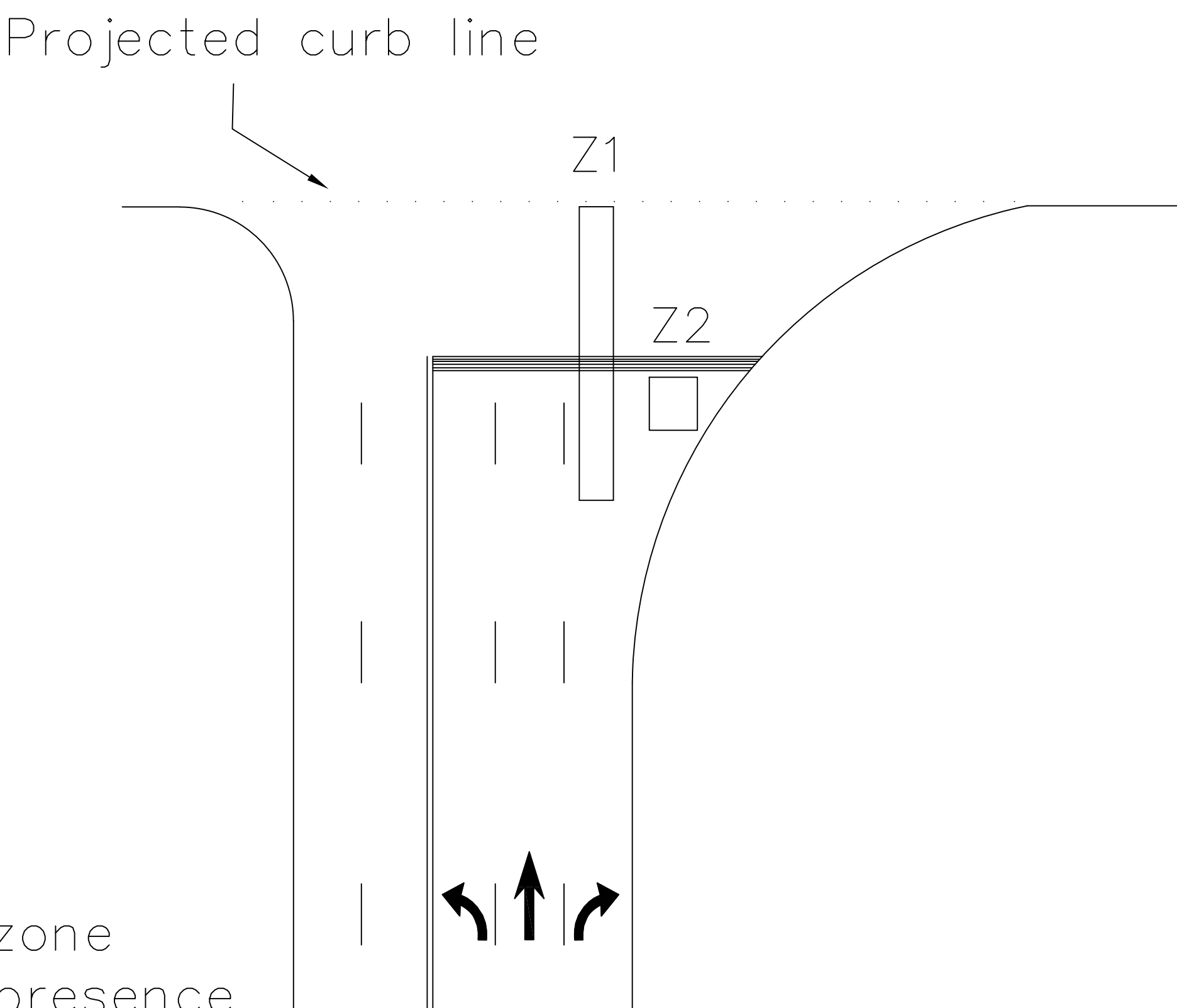
Detector area: Z2  
Zone size: 6'x6'  
Connect to phase: None (Counting Only)  
Amp type: Normal

# RIGHT TURN DETECTOR LAYOUTS

Standard Turn



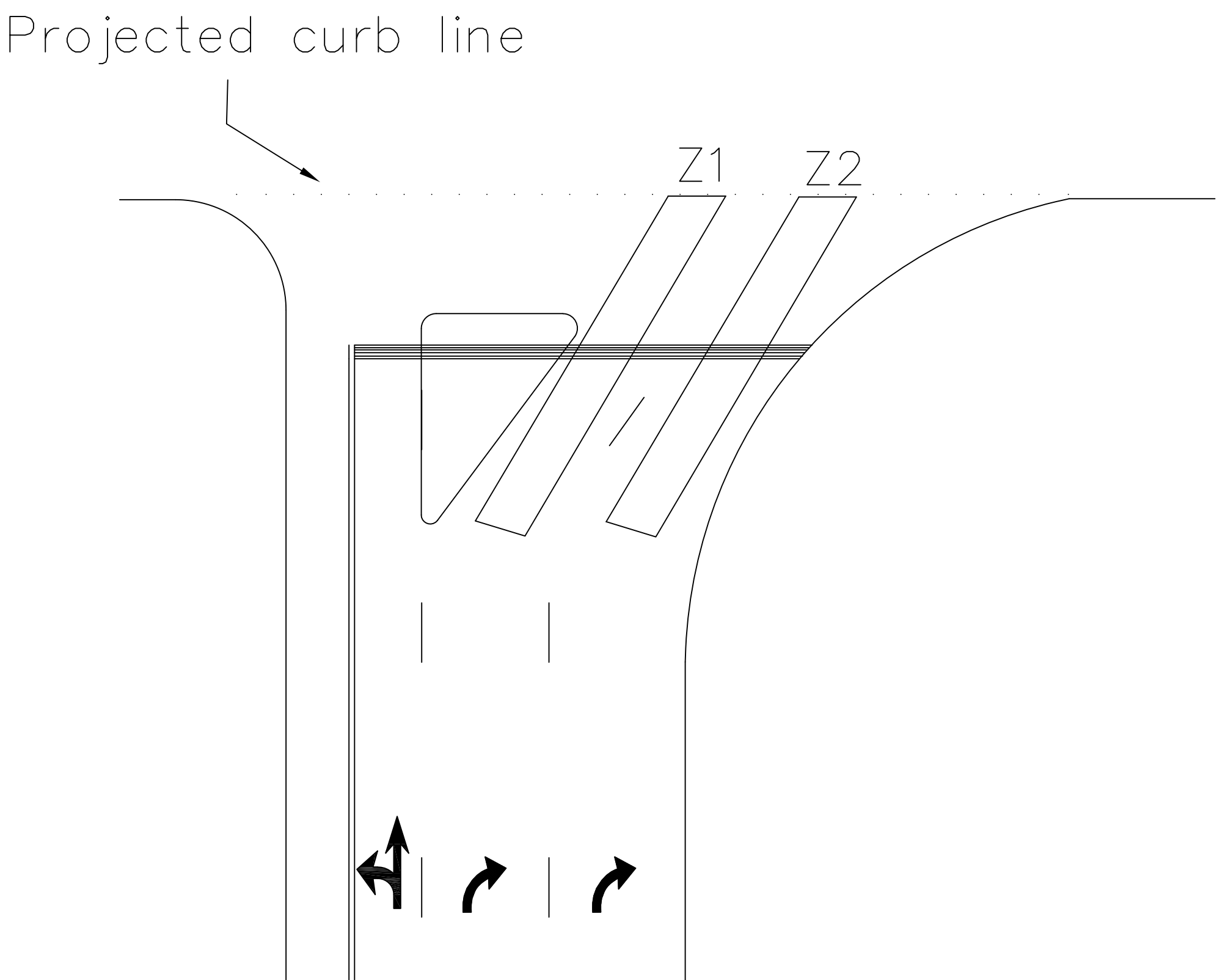
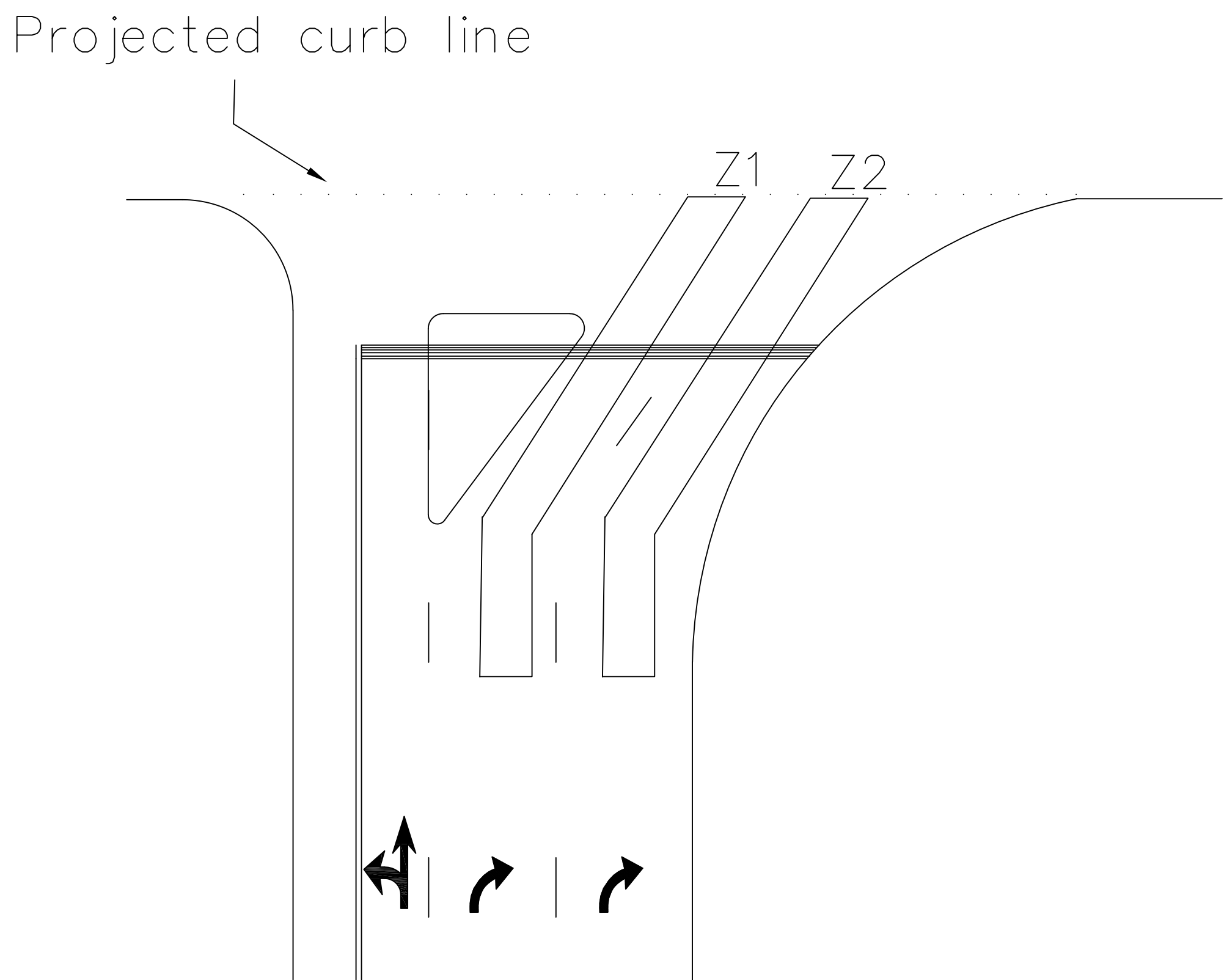
Wide Radius



Z1= 6ft x 80ft detection zone  
Z2= 6ft x 6ft (Minimum) presence  
Wired to separate detector/detection zone  
Z3= 6ft x 80ft detection zone  
Notes:

- Call delay appropriate for right turn loops unless right turn on red is prohibited. Suggested delay: 10 sec
- Do not program delay during Green.

Channelized Turn



Detection is usually deleted for Yield condition unless used for counting only.

# APPENDIX

## Amount of Inductance, Loop Wire, Sealant and Sawcut for Inductive Loops

Calculate additional loop wire or sawcut for loop wire tail section by measuring length of tail section from loop to edge of pavement.

OR

$$L \text{ (ft)} = 6 + (N - 1)12$$

Where: L = Length of loop wire or sawcut  
N = Number of lanes crossed by tail section

To calculate additional sealant for loop wire tail section:

$$S \text{ (gal)} = L \text{ (ft)} / 33$$

Where: S = Amount of sealant  
L = Length of sawcut required for tail section

Loop Dimension (feet)	Turns	Inductance (μh)	Loop Wire feet	Sealant (gal)*	Sawcut (feet)
6 X 6	3	72	72	0.8	24
	4	120	96		
	5	180	120		
	6	252	144		
6 X 15	2	63	84	1.3	42
	3	126	126		
	4	210	168		
6 X 25	2-4-2	218	224	2.7	87
6 X 30	2-4-2	258	264	3.1	102
6 X 40	2-4-2	338	344	4.0	132
6 X 50	2-4-2	418	424	5.0	162
6 X 60	2-4-2	498	504	5.9	192

\* Amount of sealant is rounded up to nearest tenth of a gallon

## Loop Wire and Lead-In Calculations

SIGNAL DESIGN SECTION  
TRANSPORTATION MOBILITY AND SAFETY DIVISION  
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO.

**4.2**

SHEET 1 OF 2

**2021-07**



## Loop Inductance Notes

- Loop inductance should be equal to or greater than the lead-in inductance.  
A 2-to-1 ratio is preferable.
- Average lead-in cable inductance is .22  $\mu\text{h}/\text{ft}$
- The minimum total inductance on a single digital detector (channel) is 50  $\mu\text{h}$ ,  
the maximum is 1000  $\mu\text{h}$ .
- The maximum number of turns is 6.
- If the loop (excluding quadrupoles) will have more than 2" of cover, add  
1 turn to the loop over the normal calculated number of turns.
- Loops connected in series  
$$L_{\text{Total}} = L_1 + L_2 + \dots + L_N$$

Where: N = Number of loops in series  
L = Loop inductance ( $\mu\text{h}$ )
- Recommended number of turns for a single 6' X 6' loop:

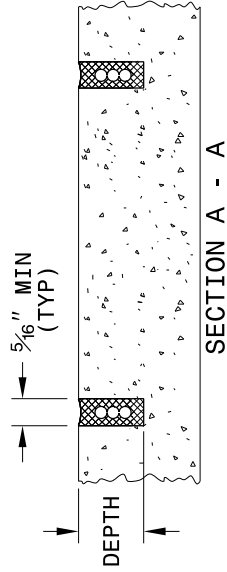
Length of Lead-in (feet)	Number of Turns
< 250	3
250-375	4
375-525	5
> 525	6

CONVENTIONAL 4-SIDED LOOP

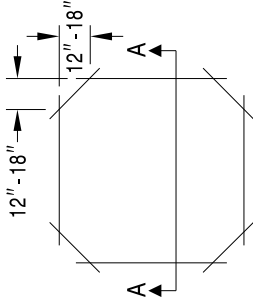
SAW CUT OPTIONS

SAW SLOT DEPTH CHART

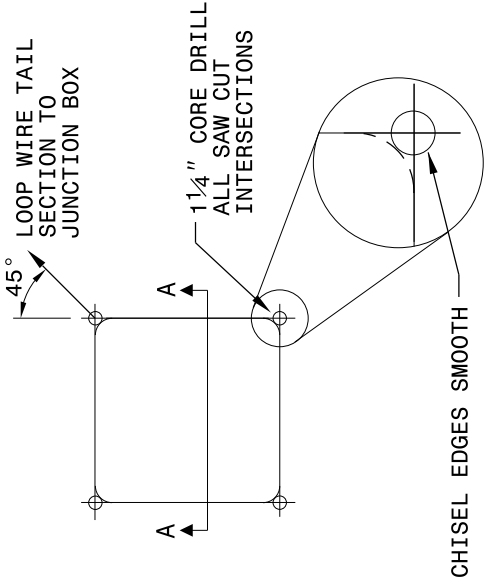
DEPTH (IN)	NO. OF WIRE TURNS				
	2	3	4	5	6
CONCRETE	2.0	2.0	2.5	2.5	3.0
ASPHALT	2.0	2.5	3.0	3.0	3.0



OPTION 1

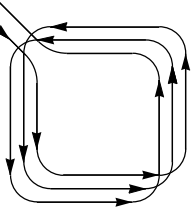


OPTION 2  
(POOR PAVEMENT)

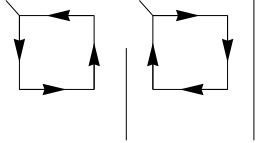


LOOP WINDING METHOD

START  
FINISH



WHEN INSTALLING 2 OR MORE LOOPS IN ADJACENT LANES, WIND LOOPS IN ALTERNATE DIRECTIONS



LOOP WIRE TWISTING METHOD

INCORRECT WAY TO TWIST WIRE



CORRECT WAY TO TWIST WIRE



NOTES

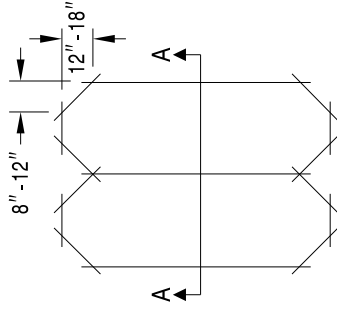
1. OVERLAP SAW CUTS AT CORNERS AND INTERSECTION POINTS TO ENSURE UNIFORM SAW SLOT DEPTH.
2. MAINTAIN 12" SPACING BETWEEN LOOP WIRE TAIL SECTIONS.
3. WIRE LOOPS CONNECTED TO THE SAME DETECTOR CHANNEL IN SERIES.
4. LOCATE LOOPS IN CENTER OF LANES UNLESS OTHERWISE SHOWN ON PLANS OR APPROVED BY ENGINEER.

ROADWAY STANDARD DRAWING FOR  
INDUCTIVE DETECTION LOOPS

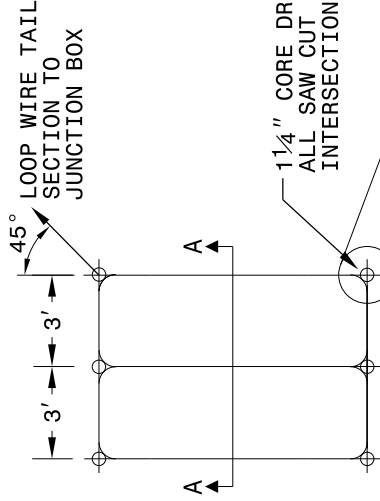
QUADRUPOLE LOOP

SAW CUT OPTIONS

OPTION 1

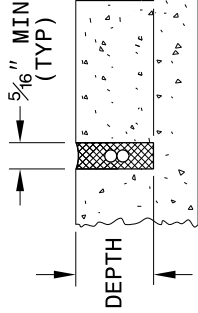
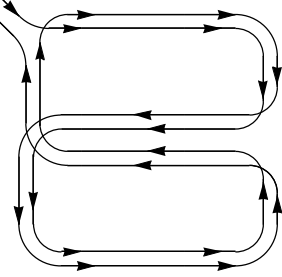


OPTION 2  
(POOR PAVEMENT)



LOOP WINDING METHOD

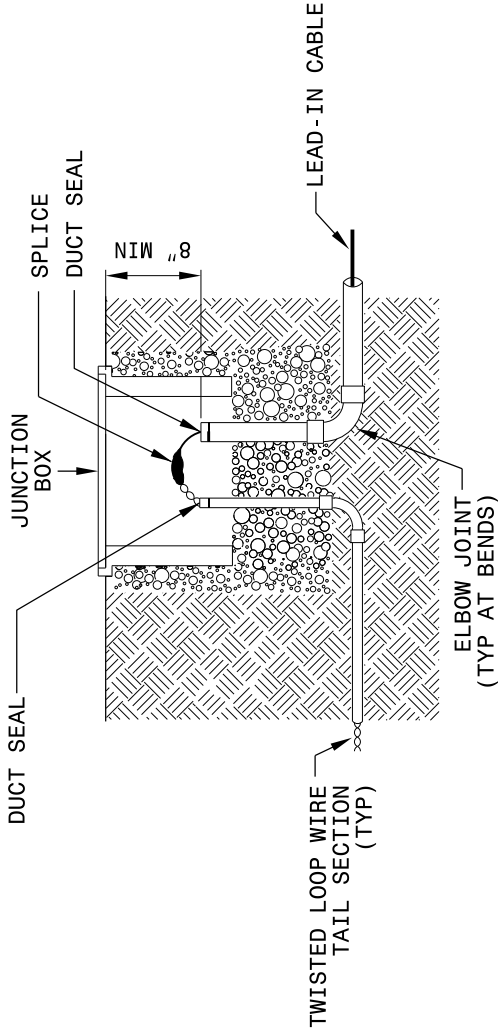
FINISH  
START



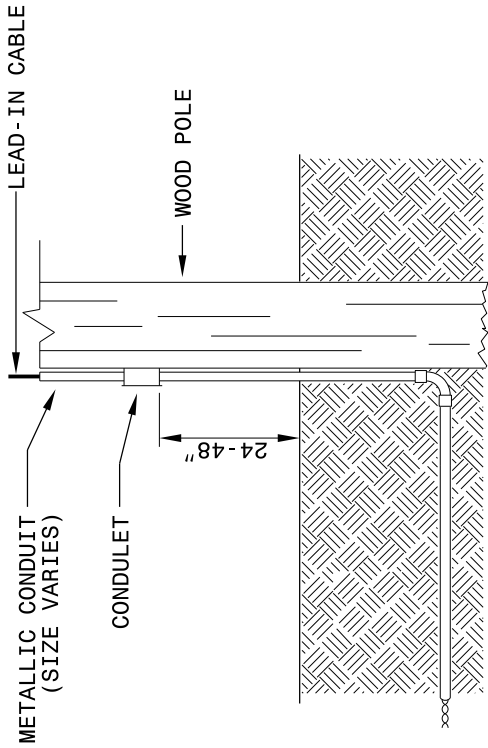
DEPTH IS 2.5" FOR CONCRETE AND 3.0" FOR ASPHALT

LOOP WIRE SPLICE POINT DETAILS

LOOP WIRE AT JUNCTION BOX



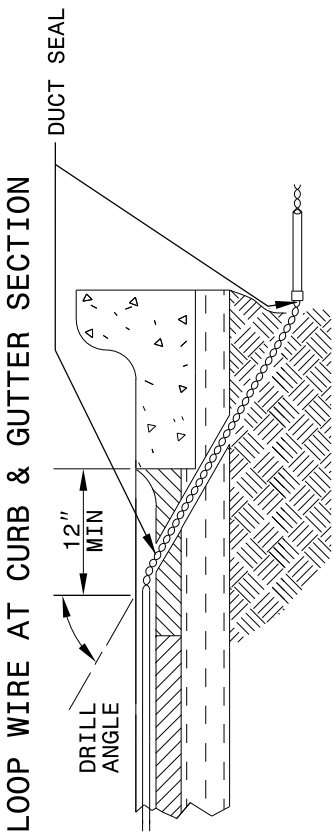
LOOP WIRE AT POLE



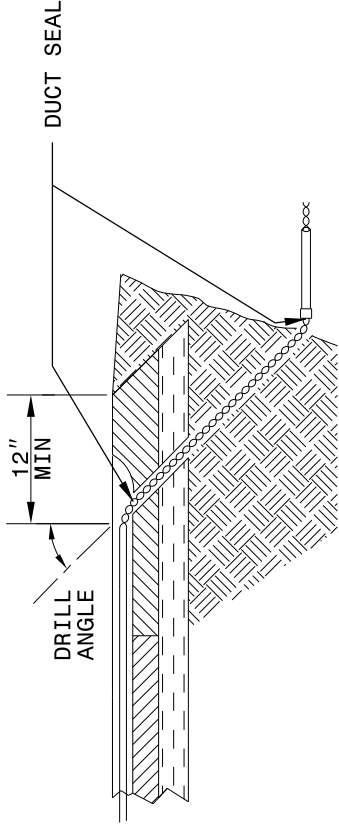
NOTE

SPLICE ALL LOOP WIRE TAIL SECTIONS/LEAD-IN CABLE IN JUNCTION BOXES OR APPROVED CONDULETS.

LOOP WIRE PAVEMENT EDGE DETAILS



LOOP WIRE AT PAVEMENT SECTION

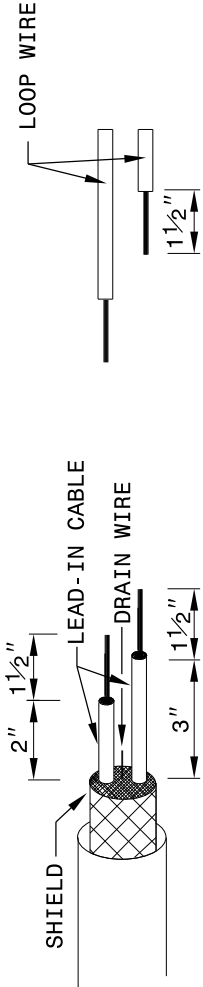


NOTES

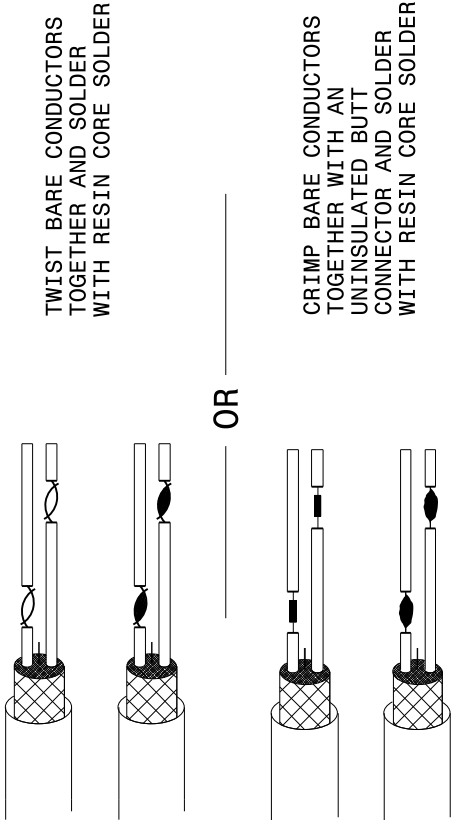
1. DO NOT EXCAVATE UNDER CURB AND GUTTER SECTIONS FOR CONDUIT INSTALLATION.
2. TWIST LOOP WIRE TAIL SECTIONS FROM WHERE LOOP WIRE TAIL LEAVES SAW CUT TO JUNCTION BOX, INCLUDING THROUGH CONDUIT.
3. BEFORE SEALING LOOPS, INSTALL DUCT SEAL WHERE LOOP WIRE TAIL SECTION LEAVES SAW CUT IN PAVEMENT AND AT ENTRANCE OF CONDUIT TO JUNCTION BOX.

ROADWAY STANDARD DRAWING FOR  
INDUCTIVE DETECTION LOOPS  
LOOP WIRE DETAILS

STEP 1. STRIP LOOP WIRE AND LEAD-IN CABLE



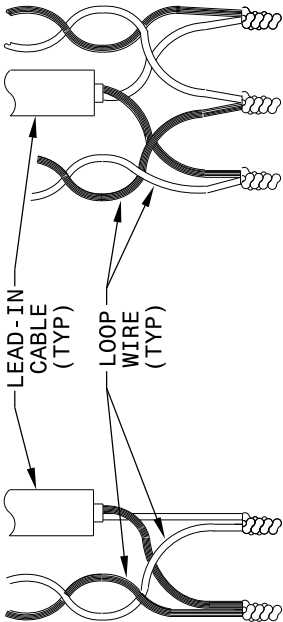
STEP 2. CONNECT AND SOLDER



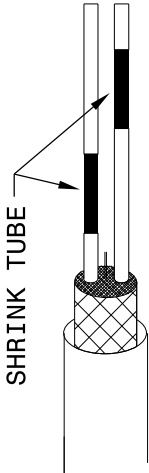
BOND SHIELD DRAIN WIRE AT SPLICE SECTIONS (DO NOT GROUND)

LOOP WIRE AND LEAD-IN CABLE CONNECTION DETAILS

SINGLE CONNECTION      SERIES CONNECTION



STEP 3. INSULATE EACH SOLDER JOINT SEPARATELY



STEP 4. ENVIRONMENTALLY PROTECT SPLICE

