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| CULVERT<br>SIZE<br>DIAMETER<br>(in.) | 1 ½ : 1 Slope  |                    |                    |                    | 2 : 1 Slope    |                    |                    |                    |
|--------------------------------------|----------------|--------------------|--------------------|--------------------|----------------|--------------------|--------------------|--------------------|
|                                      | EC-3<br>Type B | Depth (T)<br>(18") | Depth (T)<br>(24") | Depth (T)<br>(36") | EC-3<br>Type B | Depth (T)<br>(18") | Depth (T)<br>(24") | Depth (T)<br>(36") |
|                                      |                | Class A1           | Class I            | Class II           |                | Class A1           | Class I            | Class II           |
|                                      | Sq. Yds.       | Cu. Yds.           | Cu. Yds.           | Cu. Yds.           | Sq. Yds.       | Cu. Yds.           | Cu. Yds.           | Cu. Yds.           |
| 12                                   | 1.59           | 0.79               | 1.06               | 1.59               | 1.50           | 0.75               | 1.00               | 1.50               |
| 15                                   | 2.49           | 1.24               | 1.66               | 2.49               | 2.34           | 1.17               | 1.56               | 2.34               |
| 18                                   | 3.61           | 1.81               | 2.41               | 3.61               | 3.39           | 1.69               | 2.26               | 3.39               |
| 24                                   | 6.39           | 3.19               | 4.26               | 6.39               | 6.00           | 3.00               | 4.00               | 6.00               |
| 30                                   | 9.97           | 4.99               | 6.65               | 9.97               | 9.37           | 4.69               | 6.25               | 9.37               |
| 36                                   | 21.18          | 10.59              | 14.12              | 21.18              | 19.97          | 9.98               | 13.31              | 19.97              |
| 42                                   | 28.55          | 14.27              | 19.03              | 28.55              | 26.91          | 13.46              | 17.94              | 26.91              |
| 48                                   | 36.93          | 18.47              | 24.62              | 36.93              | 34.80          | 17.40              | 23.20              | 34.80              |
| 54                                   | 46.53          | 23.27              | 31.02              | 46.53              | 43.82          | 21.91              | 29.21              | 43.82              |
| 60                                   | 57.23          | 28.61              | 38.15              | 57.23              | 53.24          | 26.62              | 35.49              | 53.24              |

**TABLE D-1 CULVERT OUTLET PROTECTION WITH ST'D. ES-1 END SECTIONS**

| CULVERT<br>SIZE<br>DIAMETER<br>(in.) | 1 ½ : 1 Slope  |                    |                    |                    | 2 : 1 Slope    |                    |                    |                    |
|--------------------------------------|----------------|--------------------|--------------------|--------------------|----------------|--------------------|--------------------|--------------------|
|                                      | EC-3<br>Type B | Depth (T)<br>(18") | Depth (T)<br>(24") | Depth (T)<br>(36") | EC-3<br>Type B | Depth (T)<br>(18") | Depth (T)<br>(24") | Depth (T)<br>(36") |
|                                      |                | Class A1           | Class I            | Class II           |                | Class A1           | Class I            | Class II           |
|                                      | Sq. Yds.       | Cu. Yds.           | Cu. Yds.           | Cu. Yds.           | Sq. Yds.       | Cu. Yds.           | Cu. Yds.           | Cu. Yds.           |
| 12                                   | 1.78           | 0.89               | 1.19               | 1.78               | 1.69           | 0.85               | 1.13               | 1.69               |
| 15                                   | 2.77           | 1.39               | 1.85               | 2.77               | 2.62           | 1.31               | 1.75               | 2.62               |
| 18                                   | 3.99           | 1.99               | 2.66               | 3.99               | 3.76           | 1.88               | 2.51               | 3.76               |
| 24                                   | 7.05           | 3.52               | 4.70               | 7.05               | 6.64           | 3.32               | 4.43               | 6.64               |
| 30                                   | 10.96          | 5.48               | 7.31               | 10.96              | 10.35          | 5.17               | 6.90               | 10.35              |
| 36                                   | 22.56          | 11.28              | 15.04              | 22.56              | 21.33          | 10.67              | 14.22              | 21.33              |
| 42                                   | 30.69          | 15.35              | 20.46              | 30.69              | 29.01          | 14.51              | 19.34              | 29.01              |
| 48                                   | 39.68          | 19.84              | 26.45              | 39.68              | 37.47          | 18.74              | 24.98              | 37.47              |
| 54                                   | 49.98          | 24.99              | 33.32              | 49.98              | 47.21          | 23.60              | 31.47              | 47.21              |
| 60                                   | 61.53          | 30.77              | 41.02              | 61.53              | 57.45          | 28.73              | 38.30              | 57.45              |

**TABLE D-2 CULVERT OUTLET PROTECTION WITH ST'D. ES-2 END SECTIONS**

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.\*

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| PIPE<br>ARCH<br>SPAN<br>RISE<br>(in) | 1 ½ : 1 Slope  |                    |                    |                    | 2 : 1 Slope    |                    |                    |                    |
|--------------------------------------|----------------|--------------------|--------------------|--------------------|----------------|--------------------|--------------------|--------------------|
|                                      | EC-3<br>Type B | Depth (T)<br>(18") | Depth (T)<br>(24") | Depth (T)<br>(36") | EC-3<br>Type B | Depth (T)<br>(18") | Depth (T)<br>(24") | Depth (T)<br>(36") |
|                                      |                | Class A1           | Class I            | Class II           |                | Class A1           | Class I            | Class II           |
|                                      | Sq. Yds.       | Cu. Yds.           | Cu. Yds.           | Cu. Yds.           | Sq. Yds.       | Cu. Yds.           | Cu. Yds.           | Cu. Yds.           |
| 17 x 13                              | 2.73           | 1.36               | 1.82               | 2.73               | 2.59           | 1.30               | 1.73               | 2.59               |
| 21 x 15                              | 3.93           | 1.96               | 2.62               | 3.93               | 3.67           | 1.84               | 2.45               | 3.67               |
| 24 x 18                              | 8.34           | 4.17               | 5.56               | 8.34               | 4.99           | 2.50               | 3.33               | 4.99               |
| 28 x 20                              | 6.97           | 3.49               | 4.65               | 6.97               | 6.51           | 3.25               | 4.34               | 6.51               |
| 35 x 24                              | 10.59          | 5.29               | 7.06               | 10.59              | 9.88           | 4.94               | 6.59               | 9.88               |
| 42 x 29                              | 24.74          | 12.37              | 16.49              | 24.74              | 23.27          | 11.63              | 15.51              | 23.27              |
| 49 x 33                              | 33.14          | 16.57              | 22.09              | 33.14              | 31.14          | 15.57              | 20.76              | 31.14              |
| 57 x 38                              | 44.43          | 22.22              | 29.62              | 44.43              | 41.73          | 20.87              | 27.82              | 41.73              |
| 64 x 43                              | 56.52          | 28.26              | 37.68              | 56.52              | 53.12          | 26.56              | 35.41              | 53.12              |
| 71 x 47                              | 69.42          | 34.71              | 46.28              | 69.42              | 65.24          | 32.62              | 43.49              | 65.24              |
|                                      |                |                    |                    |                    |                |                    |                    |                    |

**TABLE D-3 CULVERT OUTLET PROTECTION WITH ST'D. ES-3 END SECTIONS**

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.\*

| CULVERT<br>SIZE<br>DIAMETER<br>(in.) | 1 ½ : 1 Slope  |                    |                    |                    | 2 : 1 Slope    |                    |                    |                    |
|--------------------------------------|----------------|--------------------|--------------------|--------------------|----------------|--------------------|--------------------|--------------------|
|                                      | EC-3<br>Type B | Depth (T)<br>(18") | Depth (T)<br>(24") | Depth (T)<br>(36") | EC-3<br>Type B | Depth (T)<br>(18") | Depth (T)<br>(24") | Depth (T)<br>(36") |
|                                      |                | Class A1           | Class I            | Class II           |                | Class A1           | Class I            | Class II           |
|                                      | Sq. Yds.       | Cu. Yds.           | Cu. Yds.           | Cu. Yds.           | Sq. Yds.       | Cu. Yds.           | Cu. Yds.           | Cu. Yds.           |
| 12                                   | 1.09           | 0.55               | 0.73               | 1.09               | 1.03           | 0.52               | 0.69               | 1.03               |
| 15                                   | 1.71           | 0.85               | 1.14               | 1.71               | 1.62           | 0.81               | 1.08               | 1.62               |
| 18                                   | 2.47           | 1.24               | 1.65               | 2.47               | 2.34           | 1.17               | 1.56               | 2.34               |
| 24                                   | 4.39           | 2.20               | 2.93               | 4.39               | 4.17           | 2.08               | 2.78               | 4.17               |
| 30                                   | 6.88           | 3.44               | 4.59               | 6.88               | 6.54           | 3.27               | 4.36               | 6.54               |
| 36                                   | 16.76          | 8.38               | 11.17              | 16.76              | 15.93          | 7.97               | 10.62              | 15.93              |

**TABLE D-4 CULVERT OUTLET PROTECTION WITH ST'D. EW-1 ENDWALLS**

| CULVERT<br>SIZE<br>DIAMETER<br>(in.) | Increments For Each Additional Pipe |          |                                |          |                               |          |                                |          |
|--------------------------------------|-------------------------------------|----------|--------------------------------|----------|-------------------------------|----------|--------------------------------|----------|
|                                      | EC-3<br>Type B                      |          | Depth (T)<br>(18")<br>Class A1 |          | Depth (T)<br>(24")<br>Class I |          | Depth (T)<br>(36")<br>Class II |          |
|                                      | Conc.                               | C. M.    | Conc.                          | C. M.    | Conc.                         | C. M.    | Conc.                          | C. M.    |
|                                      | Sq. Yds.                            | Sq. Yds. | Cu. Yds.                       | Cu. Yds. | Cu. Yds.                      | Cu. Yds. | Cu. Yds.                       | Cu. Yds. |
| 12                                   | 0.52                                | 0.45     | 0.26                           | 0.22     | 0.35                          | 0.30     | 0.52                           | 0.45     |
| 15                                   | 0.81                                | 0.70     | 0.40                           | 0.35     | 0.54                          | 0.47     | 0.81                           | 0.70     |
| 18                                   | 1.18                                | 1.03     | 0.59                           | 0.51     | 0.79                          | 0.69     | 1.18                           | 1.03     |
| 24                                   | 2.07                                | 1.83     | 1.03                           | 0.91     | 1.38                          | 1.22     | 2.07                           | 1.83     |
| 30                                   | 3.25                                | 2.88     | 1.63                           | 1.44     | 2.17                          | 1.92     | 3.25                           | 2.88     |
| 36                                   | 6.74                                | 5.53     | 3.37                           | 3.43     | 4.49                          | 4.13     | 6.74                           | 5.33     |

**TABLE D-5 CULVERT OUTLET PROTECTION WITH ST'D. EW-6 ENDWALLS**

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.\*

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| ELLIPTICAL<br>PIPE<br>SPAN RISE<br>(in.) | 1 ½ : 1 Slope  |                    |                    |                    | 2 : 1 Slope    |                    |                    |                    |
|--|----------------|--------------------|--------------------|--------------------|----------------|--------------------|--------------------|--------------------|
|  | EC-3<br>Type B | Depth (T)<br>(18") | Depth (T)<br>(24") | Depth (T)<br>(36") | EC-3<br>Type B | Depth (T)<br>(18") | Depth (T)<br>(24") | Depth (T)<br>(36") |
|  |                | Class A1           | Class I            | Class II           |                | Class A1           | Class I            | Class II           |
| Sq.<br>Yds.                              | Cu. Yds.       | Cu. Yds.           | Cu. Yds.           | Sq. Yds.           | Cu. Yds.       | Cu. Yds.           | Cu. Yds.           |                    |
| 23 x 14                                  | 2.43           | 1.21               | 1.62               | 2.43               | 2.31           | 1.15               | 1.54               | 2.31               |
| 30 x 19                                  | 4.35           | 2.17               | 2.90               | 4.35               | 4.12           | 2.06               | 2.75               | 4.12               |
| 34 x 22                                  | 5.71           | 2.85               | 3.81               | 5.71               | 5.41           | 2.71               | 3.61               | 5.41               |
| 38 x 24                                  | 6.94           | 3.47               | 4.63               | 6.94               | 6.60           | 3.30               | 4.40               | 6.60               |
| 42 x 27                                  | 8.67           | 4.33               | 5.78               | 8.67               | 8.25           | 4.12               | 5.49               | 8.23               |
| 45 x 29                                  | 9.97           | 4.99               | 6.65               | 9.97               | 9.46           | 4.73               | 6.31               | 9.46               |
| 49 x 32                                  | 12.01          | 6.00               | 8.01               | 12.01              | 11.40          | 5.70               | 7.60               | 11.40              |
| 53 x 34                                  | 13.78          | 6.89               | 9.19               | 13.78              | 13.09          | 6.55               | 8.73               | 13.09              |

**TABLE D-6 CULVERT OUTLET PROTECTION WITH ST'D. EW-2S AND EW-7S  
ENDWALLS (30° SKEW)**

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.\*

| CULVERT<br>SIZE<br>DIAMETER<br>(in.) | 1 ½ : 1 Slope  |                      |                     |                      | 2 : 1 Slope    |                      |                     |                      |
|--------------------------------------|----------------|----------------------|---------------------|----------------------|----------------|----------------------|---------------------|----------------------|
|                                      | EC-3<br>Type B | Depth (T)<br>(18")   | Depth (T)<br>(24")  | Depth (T)<br>(36")   | EC-3<br>Type B | Depth (T)<br>(18")   | Depth (T)<br>(24")  | Depth (T)<br>(36")   |
|                                      | Sq. Yds.       | Class A1<br>Cu. Yds. | Class I<br>Cu. Yds. | Class II<br>Cu. Yds. | Sq. Yds.       | Class A1<br>Cu. Yds. | Class I<br>Cu. Yds. | Class II<br>Cu. Yds. |
| 42                                   | 25.46          | 12.73                | 16.97               | 25.46                | 23.91          | 11.96                | 15.94               | 23.91                |
| 48                                   | 33.29          | 16.64                | 22.19               | 33.29                | 31.25          | 15.62                | 20.83               | 31.25                |
| 54                                   | 42.02          | 21.01                | 28.01               | 42.02                | 39.56          | 19.78                | 26.37               | 39.56                |
| 60                                   | 52.04          | 26.02                | 34.69               | 52.04                | 48.20          | 24.10                | 32.13               | 48.20                |
| 66                                   | 63.29          | 31.64                | 42.19               | 63.29                | 59.15          | 29.57                | 39.43               | 59.15                |
| 72                                   | 75.03          | 37.52                | 50.02               | 75.03                | 70.41          | 35.21                | 46.94               | 70.41                |
| 78                                   | 88.08          | 44.04                | 58.72               | 88.08                | 82.67          | 41.33                | 55.11               | 82.67                |
| 84                                   | 102.17         | 51.08                | 68.11               | 102.17               | 95.90          | 47.95                | 63.93               | 95.90                |

**TABLE D-7 CULVERT OUTLET PROTECTION WITH ST'D. EW-2 ENDWALLS**

| CULVERT<br>SIZE<br>DIAMETER<br>(in.) | Increments For Each Additional Pipe |                                |                               |                                |
|--------------------------------------|-------------------------------------|--------------------------------|-------------------------------|--------------------------------|
|                                      | EC-3<br>Type B                      | Depth (T)<br>(18")<br>Class A1 | Depth (T)<br>(24")<br>Class I | Depth (T)<br>(36")<br>Class II |
|                                      | Conc.                               | Conc.                          | Conc.                         | Conc.                          |
|                                      | Sq. Yds.                            | Cu. Yds.                       | Cu. Yds.                      | Cu. Yds.                       |
| 42                                   | 11.67                               | 5.83                           | 7.78                          | 11.67                          |
| 48                                   | 15.17                               | 7.58                           | 10.11                         | 15.17                          |
| 54                                   | 19.17                               | 9.58                           | 12.78                         | 19.17                          |
| 60                                   | 23.60                               | 11.80                          | 15.73                         | 23.60                          |
| 66                                   | 28.51                               | 14.26                          | 19.01                         | 28.51                          |
| 72                                   | 33.90                               | 16.95                          | 22.60                         | 33.90                          |
| 78                                   | 39.71                               | 19.86                          | 26.48                         | 39.71                          |
| 84                                   | 46.01                               | 23.01                          | 30.68                         | 46.01                          |

**TABLE D-8 CULVERT OUTLET PROTECTION WITH ST'D. EW-7 ENDWALLS**

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.\*

| CULVERT<br>SIZE<br>DIAMETER<br>(in.) | 1 ½ : 1 Slope  |                                |                               |                                | 2 : 1 Slope    |                                |                               |                                |
|--------------------------------------|----------------|--------------------------------|-------------------------------|--------------------------------|----------------|--------------------------------|-------------------------------|--------------------------------|
|                                      | EC-3<br>Type B | Depth (T)<br>(18")<br>Class A1 | Depth (T)<br>(24")<br>Class I | Depth (T)<br>(36")<br>Class II | EC-3<br>Type B | Depth (T)<br>(18")<br>Class A1 | Depth (T)<br>(24")<br>Class I | Depth (T)<br>(36")<br>Class II |
|                                      | Sq. Yds.       | Cu. Yds.                       | Cu. Yds.                      | Cu. Yds.                       | Sq. Yds.       | Cu. Yds.                       | Cu. Yds.                      | Cu. Yds.                       |
| 42                                   | 26.09          | 13.04                          | 17.39                         | 26.09                          | 24.54          | 12.27                          | 16.36                         | 24.54                          |
| 48                                   | 34.11          | 17.06                          | 22.74                         | 34.11                          | 32.07          | 16.04                          | 21.38                         | 32.07                          |
| 54                                   | 43.20          | 21.60                          | 28.80                         | 43.20                          | 40.61          | 20.30                          | 27.07                         | 40.61                          |
| 60                                   | 53.34          | 26.67                          | 35.56                         | 53.34                          | 49.50          | 24.75                          | 33.00                         | 49.50                          |
| 66                                   | 64.85          | 32.42                          | 43.23                         | 64.85                          | 60.71          | 30.35                          | 40.47                         | 60.71                          |
| 72                                   | 76.89          | 38.45                          | 51.26                         | 76.89                          | 72.27          | 36.14                          | 48.18                         | 72.27                          |
| 78                                   | 90.27          | 45.14                          | 60.18                         | 90.27                          | 70.83          | 35.42                          | 47.22                         | 70.83                          |
| 84                                   | 104.70         | 52.35                          | 69.80                         | 104.70                         | 98.42          | 49.21                          | 65.61                         | 98.42                          |
|                                      |                |                                |                               |                                |                |                                |                               |                                |

**TABLE D-9 CULVERT OUTLET PROTECTION WITH ST'D. EW-2S ENDWALLS  
(30° SKEW)**

| CULVERT<br>SIZE<br>DIAMETER<br>(in.) | Increments For Each Additional Pipe |                                |                               |                                |
|--------------------------------------|-------------------------------------|--------------------------------|-------------------------------|--------------------------------|
|                                      | EC-3<br>Type B                      | Depth (T)<br>(18")<br>Class A1 | Depth (T)<br>(24")<br>Class I | Depth (T)<br>(36")<br>Class II |
|                                      | Conc.                               | Conc.                          | Conc.                         | Conc.                          |
|                                      | Sq. Yds.                            | Cu. Yds.                       | Cu. Yds.                      | Cu. Yds.                       |
| 42                                   | 13.46                               | 6.73                           | 8.98                          | 13.46                          |
| 48                                   | 17.50                               | 8.75                           | 11.66                         | 17.50                          |
| 54                                   | 22.15                               | 11.06                          | 14.76                         | 22.15                          |
| 60                                   | 27.25                               | 13.61                          | 18.17                         | 27.25                          |
| 66                                   | 32.95                               | 16.46                          | 21.96                         | 32.95                          |
| 72                                   | 39.15                               | 19.56                          | 26.10                         | 39.15                          |
| 78                                   | 45.85                               | 22.91                          | 30.57                         | 45.85                          |
| 84                                   | 53.15                               | 26.56                          | 35.43                         | 53.15                          |
|                                      |                                     |                                |                               |                                |

**TABLE D-10 CULVERT OUTLET PROTECTION WITH ST'D. EW-7S ENDWALLS  
(30° SKEW)**

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.\*



| CULVERT<br>SIZE<br>DIAMETER<br>(in.) | 1 ½ : 1 Slope  |                    |                    |                    | 2 : 1 Slope    |                    |                    |                    |
|--------------------------------------|----------------|--------------------|--------------------|--------------------|----------------|--------------------|--------------------|--------------------|
|                                      | EC-3<br>Type B | Depth (T)<br>(18") | Depth (T)<br>(24") | Depth (T)<br>(36") | EC-3<br>Type B | Depth (T)<br>(18") | Depth (T)<br>(24") | Depth (T)<br>(36") |
|                                      |                | Class A1           | Class I            | Class II           |                | Class A1           | Class I            | Class II           |
|                                      | Sq. Yds.       | Cu. Yds.           | Cu. Yds.           | Cu. Yds.           | Sq. Yds.       | Cu. Yds.           | Cu. Yds.           | Cu. Yds.           |
| 42                                   | 28.80          | 14.40              | 19.20              | 28.80              | 27.65          | 13.82              | 18.43              | 27.65              |
| 48                                   | 37.64          | 18.82              | 25.09              | 37.64              | 36.12          | 18.06              | 24.08              | 36.12              |
| 54                                   | 47.64          | 23.82              | 31.76              | 47.64              | 45.71          | 22.85              | 30.47              | 45.71              |
| 60                                   | 58.80          | 29.40              | 39.20              | 58.80              | 55.77          | 27.89              | 37.18              | 55.77              |
| 66                                   | 71.12          | 35.56              | 47.41              | 71.12              | 68.30          | 34.15              | 45.53              | 68.30              |
| 72                                   | 84.71          | 42.35              | 56.47              | 84.71              | 81.29          | 40.64              | 54.19              | 81.29              |
| 78                                   | 99.41          | 49.70              | 66.27              | 99.41              | 95.39          | 47.69              | 63.59              | 95.39              |
| 84                                   | 115.29         | 57.65              | 76.86              | 115.29             | 110.63         | 55.31              | 73.75              | 110.63             |

**TABLE D-11 CULVERT OUTLET PROTECTION WITH ST'D. EW-2S ENDWALLS  
(45° SKEW)**

| CULVERT<br>SIZE<br>DIAMETER<br>(in.) | Increments For Each Additional Pipe |                                |                               |                                |
|--------------------------------------|-------------------------------------|--------------------------------|-------------------------------|--------------------------------|
|                                      | EC-3<br>Type B                      | Depth (T)<br>(18")<br>Class A1 | Depth (T)<br>(24")<br>Class I | Depth (T)<br>(36")<br>Class II |
|                                      | Conc.                               | Conc.                          | Conc.                         | Conc.                          |
|                                      | Sq. Yds.                            | Cu. Yds.                       | Cu. Yds.                      | Cu. Yds.                       |
| 42                                   | 12.63                               | 6.32                           | 8.42                          | 12.63                          |
| 48                                   | 16.44                               | 8.22                           | 10.96                         | 16.44                          |
| 54                                   | 20.78                               | 10.39                          | 13.85                         | 20.78                          |
| 60                                   | 25.58                               | 12.79                          | 17.05                         | 25.58                          |
| 66                                   | 30.92                               | 15.46                          | 20.61                         | 30.92                          |
| 72                                   | 36.75                               | 18.38                          | 24.50                         | 36.75                          |
| 78                                   | 43.10                               | 21.55                          | 28.73                         | 43.10                          |
| 84                                   | 49.94                               | 24.97                          | 33.29                         | 49.94                          |

**TABLE D-12 CULVERT OUTLET PROTECTION WITH ST'D. EW-7S ENDWALLS  
(45° SKEW)**

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.\*

| ELLIPTICAL<br>PIPE<br>SPAN RISE<br>(in.) | 1 ½ : 1 Slope  |                                |                               |                                | 2 : 1 Slope    |                                |                               |                                |
|--|----------------|--------------------------------|-------------------------------|--------------------------------|----------------|--------------------------------|-------------------------------|--------------------------------|
|  | EC-3<br>Type B | Depth (T)<br>(18")<br>Class A1 | Depth (T)<br>(24")<br>Class I | Depth (T)<br>(36")<br>Class II | EC-3<br>Type B | Depth (T)<br>(18")<br>Class A1 | Depth (T)<br>(24")<br>Class I | Depth (T)<br>(36")<br>Class II |
|  | Sq. Yds.       | Cu. Yds.                       | Cu. Yds.                      | Cu. Yds.                       | Sq. Yds.       | Cu. Yds.                       | Cu. Yds.                      | Cu. Yds.                       |
| 60 x 38                                  | 29.10          | 14.55                          | 19.40                         | 29.10                          | 26.39          | 13.19                          | 17.59                         | 26.39                          |
| 68 x 43                                  | 37.95          | 18.98                          | 25.30                         | 37.95                          | 34.52          | 17.26                          | 23.01                         | 34.52                          |
| 76 x 48                                  | 47.31          | 23.66                          | 31.54                         | 47.31                          | 42.99          | 21.50                          | 28.66                         | 42.99                          |
| 83 x 53                                  | 57.03          | 28.52                          | 38.02                         | 57.03                          | 51.86          | 25.93                          | 34.57                         | 51.86                          |
| 91 x 58                                  | 68.34          | 34.17                          | 45.56                         | 68.34                          | 62.07          | 31.04                          | 41.38                         | 62.07                          |
| 98 x 63                                  | 80.82          | 40.41                          | 53.88                         | 80.82                          | 72.66          | 36.33                          | 48.44                         | 72.66                          |
| 106 x 68                                 | 93.35          | 46.67                          | 62.23                         | 93.35                          | 84.74          | 42.37                          | 56.49                         | 84.74                          |
|  |                |                                |                               |                                |                |                                |                               |                                |
|  |                |                                |                               |                                |                |                                |                               |                                |

**TABLE D-13 CULVERT OUTLET PROTECTION WITH ST'D. EW-2A ENDWALLS**

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.\*

\* Rev. 7/10

| PIPE ARCH<br><br>Span Riser<br>(in.) | 1 ½ : 1 Slope |                 |                 |                 | 2 : 1 Slope |                 |                 |                 |
|--------------------------------------|---------------|-----------------|-----------------|-----------------|-------------|-----------------|-----------------|-----------------|
|                                      | EC-3 Type B   | Depth (T) (18") | Depth (T) (24") | Depth (T) (36") | EC-3 Type B | Depth (T) (18") | Depth (T) (24") | Depth (T) (36") |
|                                      |               | Class A1        | Class I         | Class II        |             | Class A1        | Class I         | Class II        |
|                                      | Sq. Yds.      | Cu. Yds.        | Cu. Yds.        | Cu. Yds.        | Sq. Yds.    | Cu. Yds.        | Cu. Yds.        | Cu. Yds.        |
| 17 x 13                              | 1.68          | 0.84            | 1.12            | 1.68            | 1.59        | 0.79            | 1.06            | 1.59            |
| 21 x 15                              | 2.40          | 1.20            | 1.60            | 2.40            | 2.28        | 1.14            | 1.52            | 2.28            |
| 24 x 18                              | 3.30          | 1.65            | 2.20            | 3.30            | 3.13        | 1.57            | 2.09            | 3.13            |
| 28 x 20                              | 4.29          | 2.14            | 2.86            | 4.29            | 4.06        | 2.03            | 2.71            | 4.06            |
| 35 x 24                              | 6.40          | 3.20            | 4.27            | 6.40            | 6.07        | 3.04            | 4.05            | 6.07            |
| 42 x 29                              | 9.30          | 4.65            | 6.20            | 9.30            | 8.83        | 4.42            | 5.89            | 8.83            |
| 49 x 33                              | 12.40         | 6.20            | 8.27            | 12.40           | 11.77       | 5.89            | 7.85            | 11.77           |
| 57 x 38                              | 24.33         | 12.11           | 16.15           | 24.33           | 23.03       | 11.51           | 15.35           | 23.03           |

**TABLE D-14 CULVERT OUTLET PROTECTION WITH ST'D. EW-9 PIPE ARCHES**

| PIPE ARCH<br><br>Span Riser<br>(in.) | Increments For Each Additional Pipe |                             |                            |                             |
|--------------------------------------|-------------------------------------|-----------------------------|----------------------------|-----------------------------|
|                                      | EC-3 Type B                         | Depth (T) (18")<br>Class A1 | Depth (T) (24")<br>Class I | Depth (T) (36")<br>Class II |
|                                      | Conc.                               | Conc.                       | Conc.                      | Conc.                       |
|                                      | Sq. Yds.                            | Cu. Yds.                    | Cu. Yds.                   | Cu. Yds.                    |
| 17 x 13                              | 0.78                                | 0.39                        | 0.52                       | 0.78                        |
| 21 x 15                              | 1.05                                | 0.52                        | 0.70                       | 1.05                        |
| 24 x 18                              | 1.38                                | 0.69                        | 0.92                       | 1.38                        |
| 28 x 20                              | 1.71                                | 0.85                        | 1.14                       | 1.71                        |
| 35 x 24                              | 2.37                                | 1.18                        | 1.58                       | 2.37                        |
| 42 x 29                              | 3.49                                | 1.75                        | 2.33                       | 3.49                        |
| 49 x 33                              | 4.65                                | 2.32                        | 3.10                       | 4.65                        |
| 57 x 38                              | 11.33                               | 5.66                        | 7.55                       | 11.33                       |

**TABLE D-15 CULVERT OUTLET PROTECTION WITH ST'D. EW-10 PIPE ARCHES**

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.\*

\* Rev. 7/10

| CULVERT<br>SIZE<br>(FEET)<br><br>SPAN X<br>RISE | 1 ½ : 1 Slope  |                       |                       |                       | 2 : 1 Slope    |                       |                       |                       |
|---|----------------|-----------------------|-----------------------|-----------------------|----------------|-----------------------|-----------------------|-----------------------|
|   | EC-3<br>Type B | Depth<br>(T)<br>(18") | Depth<br>(T)<br>(24") | Depth<br>(T)<br>(36") | EC-3<br>Type B | Depth<br>(T)<br>(18") | Depth<br>(T)<br>(24") | Depth<br>(T)<br>(36") |
|   |                | Class A1              | Class I               | Class II              |                | Class A1              | Class I               | Class II              |
|   | Sq. Yds.       | Cu. Yds.              | Cu. Yds.              | Cu. Yds.              | Sq. Yds.       | Cu. Yds.              | Cu. Yds.              | Cu. Yds.              |
| 3 x 3   | 21.12          | 10.56                 | 14.08                 | 21.12                 | 20.39          | 10.19                 | 13.59                 | 20.39                 |
| 3 x 4   | 28.71          | 14.36                 | 19.14                 | 28.71                 | 28.26          | 14.13                 | 18.84                 | 28.26                 |
| 4 x 3   | 28.49          | 14.24                 | 18.99                 | 28.49                 | 26.85          | 13.43                 | 17.90                 | 26.85                 |
| 4 x 4   | 37.61          | 18.80                 | 25.07                 | 37.61                 | 36.41          | 18.20                 | 24.27                 | 36.41                 |
| 4 x 5   | 47.66          | 23.83                 | 31.77                 | 47.66                 | 46.86          | 23.43                 | 31.24                 | 46.86                 |
| 4 x 6   | 58.01          | 29.00                 | 38.67                 | 58.01                 | 58.34          | 29.17                 | 38.89                 | 58.34                 |
| 5 x 3   | 36.62          | 18.31                 | 24.41                 | 36.62                 | 33.95          | 16.97                 | 22.63                 | 33.95                 |
| 5 x 4   | 47.25          | 23.63                 | 31.50                 | 47.25                 | 44.78          | 22.39                 | 29.85                 | 44.78                 |
| 5 x 5   | 58.82          | 29.41                 | 39.21                 | 58.82                 | 56.72          | 28.36                 | 37.81                 | 56.72                 |
| 5 x 6   | 70.86          | 35.43                 | 47.24                 | 70.86                 | 69.62          | 34.81                 | 46.41                 | 69.62                 |
| 5 x 7   | 84.08          | 42.04                 | 56.05                 | 84.08                 | 83.45          | 41.72                 | 55.63                 | 83.45                 |
| 6 x 4   | 57.68          | 28.84                 | 38.45                 | 57.68                 | 53.93          | 26.96                 | 35.95                 | 53.93                 |
| 6 x 5   | 70.74          | 35.37                 | 47.16                 | 70.74                 | 67.20          | 33.60                 | 44.80                 | 67.20                 |
| 6 x 6   | 84.50          | 42.25                 | 56.33                 | 84.50                 | 81.54          | 40.77                 | 54.36                 | 81.54                 |
| 6 x 7   | 97.89          | 48.95                 | 65.26                 | 97.89                 | 96.83          | 48.41                 | 64.55                 | 96.83                 |
| 6 x 8   | 114.17         | 57.08                 | 76.11                 | 114.17                | 113.04         | 56.52                 | 75.36                 | 113.04                |
| 7 x 4   | 68.82          | 34.41                 | 45.88                 | 68.82                 | 63.77          | 31.88                 | 42.51                 | 63.77                 |
| 7 x 6   | 98.96          | 49.48                 | 65.97                 | 98.96                 | 94.10          | 47.05                 | 62.73                 | 94.10                 |
| 7 x 8   | 132.47         | 66.23                 | 88.31                 | 132.47                | 128.49         | 64.25                 | 85.66                 | 128.49                |
| 7 x 10  | 167.46         | 83.73                 | 111.64                | 167.46                | 165.53         | 82.76                 | 110.35                | 165.53                |
| 8 x 4   | 80.73          | 40.37                 | 53.82                 | 80.73                 | 74.30          | 37.15                 | 49.53                 | 74.30                 |
| 8 x 6   | 114.09         | 57.05                 | 76.06                 | 114.09                | 107.36         | 53.68                 | 71.57                 | 107.36                |
| 8 x 8   | 150.47         | 75.23                 | 100.31                | 150.47                | 145.11         | 72.56                 | 96.74                 | 145.11                |
| 8 x 10  | 189.00         | 94.50                 | 126.00                | 189.00                | 174.18         | 87.09                 | 116.12                | 174.18                |
| 9 x 4   | 93.39          | 46.70                 | 62.26                 | 93.39                 | 85.47          | 42.74                 | 56.98                 | 85.47                 |
| 9 x 6   | 130.17         | 65.09                 | 86.78                 | 130.17                | 121.41         | 60.71                 | 80.94                 | 121.41                |
| 9 x 8   | 163.32         | 81.66                 | 108.88                | 163.32                | 161.72         | 80.86                 | 107.81                | 161.72                |
| 9 x 10  | 211.31         | 105.65                | 140.87                | 211.31                | 217.35         | 108.68                | 144.90                | 217.35                |
| 9 x 12  | 256.28         | 128.14                | 170.85                | 256.28                | 293.36         | 146.68                | 195.57                | 293.36                |
| 10 x 4  | 106.83         | 53.42                 | 71.22                 | 106.83                | 97.31          | 48.65                 | 64.87                 | 97.31                 |
| 10 x 6  | 147.00         | 73.50                 | 98.00                 | 147.00                | 136.13         | 68.06                 | 90.75                 | 136.13                |
| 10 x 8  | 189.03         | 94.52                 | 126.02                | 189.03                | 179.00         | 89.50                 | 119.33                | 179.00                |
| 10 x 10   | 234.86         | 117.43                | 156.57                | 234.86                | 226.31         | 113.15                | 150.87                | 226.31                |
| 10 x 12   | 283.50         | 141.75                | 189.00                | 283.50                | 277.40         | 138.70                | 184.93                | 277.40                |
| 12 x 6  | 182.09         | 91.04                 | 121.39                | 182.09                | 168.32         | 84.16                 | 112.21                | 168.32                |
| 12 x 8  | 231.05         | 115.52                | 154.03                | 231.05                | 215.67         | 107.84                | 143.78                | 215.67                |
| 12 x 10   | 283.01         | 141.50                | 188.67                | 283.01                | 268.80         | 134.40                | 179.20                | 268.80                |
| 12 x 12   | 338.57         | 169.28                | 225.71                | 338.57                | 326.13         | 163.07                | 217.42                | 326.13                |

**TABLE D-16 CULVERT OUTLET PROTECTION FOR BOX CULVERT ST'D BCS-02  
THRU BCS-50 (NO SKEW)**

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.\*

\* Rev. 7/10

| CULVERT<br>SIZE<br>(FEET) | 1 ½ : 1 Slope  |                       |                       |                       | 2 : 1 Slope    |                       |                       |                       |
|---------------------------|----------------|-----------------------|-----------------------|-----------------------|----------------|-----------------------|-----------------------|-----------------------|
|                           | EC-3<br>Type B | Depth<br>(T)<br>(18") | Depth<br>(T)<br>(24") | Depth<br>(T)<br>(36") | EC-3<br>Type B | Depth<br>(T)<br>(18") | Depth<br>(T)<br>(24") | Depth<br>(T)<br>(36") |
|                           |                | Class A1              | Class I               | Class II              |                | Class A1              | Class I               | Class II              |
|                           | SPAN X<br>RISE | Sq. Yds.              | Cu. Yds.              | Cu. Yds.              | Cu. Yds.       | Sq. Yds.              | Cu. Yds.              | Cu. Yds.              |
| 3 x 3                     | 21.23          | 10.61                 | 14.15                 | 21.23                 | 20.49          | 10.25                 | 13.66                 | 20.49                 |
| 3 x 4                     | 28.86          | 14.43                 | 19.24                 | 28.86                 | 28.40          | 14.20                 | 18.93                 | 28.40                 |
| 4 x 3                     | 28.62          | 14.31                 | 19.08                 | 28.62                 | 27.00          | 13.50                 | 18.00                 | 27.00                 |
| 4 x 4                     | 37.80          | 18.90                 | 25.20                 | 37.80                 | 36.59          | 18.29                 | 24.39                 | 36.59                 |
| 4 x 5                     | 47.90          | 23.95                 | 31.93                 | 47.90                 | 47.13          | 23.57                 | 31.42                 | 47.13                 |
| 4 x 6                     | 58.29          | 29.15                 | 38.86                 | 58.29                 | 58.62          | 29.31                 | 39.08                 | 58.62                 |
| 5 x 3                     | 36.50          | 18.25                 | 24.33                 | 36.50                 | 34.13          | 17.06                 | 22.75                 | 34.13                 |
| 5 x 4                     | 47.48          | 23.74                 | 31.65                 | 47.48                 | 45.00          | 22.50                 | 30.00                 | 45.00                 |
| 5 x 5                     | 59.12          | 29.56                 | 39.41                 | 59.12                 | 57.02          | 28.51                 | 38.01                 | 57.02                 |
| 5 x 6                     | 71.21          | 35.60                 | 47.47                 | 71.21                 | 69.96          | 34.98                 | 46.64                 | 69.96                 |
| 5 x 7                     | 84.50          | 42.25                 | 56.33                 | 84.50                 | 83.87          | 41.93                 | 55.91                 | 83.87                 |
| 6 x 4                     | 57.96          | 28.98                 | 38.64                 | 57.96                 | 54.21          | 27.11                 | 36.14                 | 54.21                 |
| 6 x 5                     | 71.10          | 35.55                 | 47.40                 | 71.10                 | 67.56          | 33.78                 | 45.04                 | 67.56                 |
| 6 x 6                     | 84.93          | 42.47                 | 56.62                 | 84.93                 | 81.98          | 40.99                 | 54.65                 | 81.98                 |
| 6 x 7                     | 98.39          | 49.19                 | 65.59                 | 98.39                 | 97.32          | 48.66                 | 64.88                 | 97.32                 |
| 6 x 8                     | 114.72         | 57.36                 | 76.48                 | 114.72                | 113.61         | 56.81                 | 75.74                 | 113.61                |
| 7 x 4                     | 69.17          | 34.58                 | 46.11                 | 69.17                 | 64.10          | 32.05                 | 42.73                 | 64.10                 |
| 7 x 6                     | 99.45          | 49.73                 | 66.30                 | 99.45                 | 30.18          | 15.09                 | 20.12                 | 30.18                 |
| 7 x 8                     | 197.39         | 98.69                 | 131.59                | 197.39                | 129.15         | 64.58                 | 86.10                 | 129.15                |
| 7 x 10                    | 168.27         | 84.14                 | 112.18                | 168.27                | 166.35         | 83.18                 | 110.90                | 166.35                |
| 8 x 4                     | 81.11          | 40.55                 | 54.07                 | 81.11                 | 74.67          | 37.34                 | 49.78                 | 74.67                 |
| 8 x 6                     | 114.65         | 57.32                 | 76.43                 | 114.65                | 107.91         | 53.96                 | 71.94                 | 107.91                |
| 8 x 8                     | 151.22         | 75.61                 | 100.81                | 151.22                | 145.86         | 72.93                 | 97.24                 | 145.86                |
| 8 x 10                    | 189.95         | 94.97                 | 126.63                | 189.95                | 175.11         | 87.56                 | 116.74                | 175.11                |
| 9 x 4                     | 93.83          | 46.91                 | 62.55                 | 93.83                 | 85.89          | 42.95                 | 57.26                 | 85.89                 |
| 9 x 6                     | 130.80         | 65.40                 | 87.20                 | 130.80                | 122.04         | 61.02                 | 81.36                 | 122.04                |
| 9 x 8                     | 164.18         | 82.09                 | 109.45                | 164.18                | 162.57         | 81.29                 | 108.38                | 162.57                |
| 9 x 10                    | 212.37         | 106.19                | 141.58                | 212.37                | 218.42         | 109.21                | 145.61                | 218.42                |
| 9 x 12                    | 257.54         | 128.77                | 171.69                | 257.54                | 294.63         | 147.32                | 196.42                | 294.63                |
| 10 x 4                    | 107.30         | 53.65                 | 71.53                 | 107.30                | 97.77          | 48.89                 | 65.18                 | 97.77                 |
| 10 x 6                    | 147.71         | 73.85                 | 98.47                 | 147.71                | 136.83         | 68.42                 | 91.22                 | 136.83                |
| 10 x 8                    | 189.98         | 94.99                 | 126.65                | 189.98                | 179.93         | 89.96                 | 119.95                | 179.93                |
| 10 x 10                   | 236.03         | 118.01                | 157.35                | 236.03                | 227.48         | 113.74                | 151.65                | 227.48                |
| 10 x 12                   | 284.91         | 142.46                | 189.94                | 284.91                | 278.81         | 139.40                | 185.87                | 278.81                |
| 12 x 6                    | 182.94         | 91.47                 | 121.96                | 182.94                | 169.17         | 84.59                 | 112.78                | 169.17                |
| 12 x 8                    | 232.17         | 116.09                | 154.78                | 232.17                | 216.80         | 108.40                | 144.53                | 216.80                |
| 12 x 10                   | 284.42         | 142.21                | 189.61                | 284.42                | 270.21         | 135.11                | 180.14                | 270.21                |
| 12 x 12                   | 340.26         | 170.13                | 226.84                | 340.26                | 327.83         | 163.91                | 218.55                | 327.83                |

**TABLE D-17 CULVERT OUTLET PROTECTION FOR BOX CULVERT ST'D BCS-02 THRU BCS-50 (15° SKEW)**

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.\*

\* Rev. 7/10

| CULVERT<br>SIZE<br>(FEET)<br><br>SPAN X<br>RISE | 1 ½ : 1 Slope  |                       |                       |                       | 2 : 1 Slope    |                       |                       |                       |
|---|----------------|-----------------------|-----------------------|-----------------------|----------------|-----------------------|-----------------------|-----------------------|
|   | EC-3<br>Type B | Depth<br>(T)<br>(18") | Depth<br>(T)<br>(24") | Depth<br>(T)<br>(36") | EC-3<br>Type B | Depth<br>(T)<br>(18") | Depth<br>(T)<br>(24") | Depth<br>(T)<br>(36") |
|   |                | Class A1              | Class I               | Class II              |                | Class A1              | Class I               | Class II              |
|   | Sq. Yds.       | Cu. Yds.              | Cu. Yds.              | Cu. Yds.              | Sq. Yds.       | Cu. Yds.              | Cu. Yds.              | Cu. Yds.              |
| 3 x 3   | 21.69          | 10.85                 | 14.46                 | 21.69                 | 21.03          | 10.52                 | 14.02                 | 21.03                 |
| 3 x 4   | 29.61          | 14.81                 | 19.74                 | 29.61                 | 29.40          | 14.70                 | 19.60                 | 29.40                 |
| 4 x 3   | 29.07          | 14.54                 | 19.38                 | 29.07                 | 27.48          | 13.74                 | 18.32                 | 27.48                 |
| 4 x 4   | 38.67          | 19.34                 | 25.78                 | 38.67                 | 37.59          | 18.80                 | 25.06                 | 37.59                 |
| 4 x 5   | 49.22          | 24.61                 | 32.81                 | 49.22                 | 48.87          | 24.44                 | 32.58                 | 48.87                 |
| 4 x 6   | 60.56          | 30.28                 | 40.37                 | 60.56                 | 61.35          | 30.68                 | 40.90                 | 61.35                 |
| 5 x 3   | 37.22          | 18.61                 | 24.81                 | 37.22                 | 34.55          | 17.27                 | 23.03                 | 34.55                 |
| 5 x 4   | 48.27          | 24.14                 | 32.18                 | 48.27                 | 45.90          | 22.95                 | 30.60                 | 45.90                 |
| 5 x 5   | 60.39          | 30.20                 | 40.26                 | 60.39                 | 62.21          | 31.10                 | 41.47                 | 62.21                 |
| 5 x 6   | 73.35          | 36.68                 | 48.90                 | 73.35                 | 72.50          | 36.25                 | 48.33                 | 72.50                 |
| 5 x 7   | 87.30          | 43.65                 | 58.20                 | 87.30                 | 87.38          | 43.69                 | 58.25                 | 87.38                 |
| 6 x 4   | 58.77          | 29.39                 | 39.18                 | 58.77                 | 55.04          | 27.52                 | 36.69                 | 55.04                 |
| 6 x 5   | 72.35          | 36.17                 | 48.23                 | 72.35                 | 69.00          | 34.50                 | 46.00                 | 69.00                 |
| 6 x 6   | 86.93          | 43.46                 | 57.95                 | 86.93                 | 84.30          | 42.15                 | 56.20                 | 84.30                 |
| 6 x 7   | 100.83         | 50.42                 | 67.22                 | 100.83                | 100.64         | 50.32                 | 67.09                 | 100.64                |
| 6 x 8   | 118.52         | 59.26                 | 79.01                 | 118.52                | 118.22         | 59.11                 | 78.81                 | 118.22                |
| 7 x 4   | 84.98          | 42.49                 | 56.65                 | 84.98                 | 64.86          | 32.43                 | 43.24                 | 64.86                 |
| 7 x 6   | 101.27         | 50.63                 | 67.51                 | 101.27                | 96.74          | 48.37                 | 64.49                 | 96.74                 |
| 7 x 8   | 136.32         | 68.16                 | 90.88                 | 136.32                | 133.52         | 66.76                 | 89.01                 | 133.52                |
| 7 x 10  | 174.42         | 87.21                 | 116.28                | 174.42                | 174.21         | 87.11                 | 116.14                | 174.21                |
| 8 x 4   | 81.96          | 40.98                 | 54.64                 | 81.96                 | 75.36          | 37.68                 | 50.24                 | 75.36                 |
| 8 x 6   | 116.39         | 58.19                 | 77.59                 | 116.39                | 109.85         | 54.92                 | 73.23                 | 109.85                |
| 8 x 8   | 154.32         | 77.16                 | 102.88                | 154.32                | 150.05         | 75.02                 | 100.03                | 150.05                |
| 8 x 10  | 196.26         | 98.13                 | 130.84                | 196.26                | 182.82         | 91.41                 | 121.88                | 182.82                |
| 9 x 4   | 94.68          | 47.34                 | 63.12                 | 94.68                 | 86.52          | 43.26                 | 57.68                 | 86.52                 |
| 9 x 6   | 132.45         | 66.23                 | 88.30                 | 132.45                | 123.81         | 61.91                 | 82.54                 | 123.81                |
| 9 x 8   | 167.51         | 83.75                 | 111.67                | 167.51                | 166.50         | 83.25                 | 111.00                | 166.50                |
| 9 x 10  | 218.42         | 109.21                | 145.61                | 218.42                | 225.68         | 112.84                | 150.45                | 225.68                |
| 9 x 12  | 266.64         | 133.32                | 177.76                | 266.64                | 305.79         | 152.90                | 203.86                | 305.79                |
| 10 x 4  | 108.18         | 54.09                 | 72.12                 | 108.18                | 98.34          | 49.17                 | 65.56                 | 98.34                 |
| 10 x 6  | 149.27         | 74.63                 | 99.51                 | 149.27                | 138.45         | 69.23                 | 92.30                 | 138.45                |
| 10 x 8  | 193.16         | 96.58                 | 128.77                | 193.16                | 183.66         | 91.83                 | 122.44                | 183.66                |
| 10 x 10   | 241.77         | 120.89                | 161.18                | 241.77                | 234.47         | 117.23                | 156.31                | 234.47                |
| 10 x 12   | 293.69         | 146.84                | 195.79                | 293.69                | 289.74         | 144.87                | 193.16                | 289.74                |
| 12 x 6  | 184.10         | 92.05                 | 122.73                | 184.10                | 170.30         | 85.15                 | 113.53                | 170.30                |
| 12 x 8  | 235.04         | 117.52                | 156.69                | 235.04                | 219.90         | 109.95                | 146.60                | 219.90                |
| 12 x 10   | 289.53         | 144.77                | 193.02                | 289.53                | 276.30         | 138.15                | 184.20                | 276.30                |
| 12 x 12   | 348.38         | 174.19                | 232.25                | 348.38                | 337.88         | 168.94                | 225.25                | 337.88                |

**TABLE D-18 CULVERT OUTLET PROTECTION FOR BOX CULVERT ST'D BCS-02 THRU BCS-50 (30° SKEW)**

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.\*

\* Rev. 7/10

| CULVERT<br>SIZE<br>(FEET)<br><br>SPAN X<br>RISE | 1 ½ : 1 Slope  |                       |                       |                       | 2 : 1 Slope    |                       |                       |                       |
|---|----------------|-----------------------|-----------------------|-----------------------|----------------|-----------------------|-----------------------|-----------------------|
|   | EC-3<br>Type B | Depth<br>(T)<br>(18") | Depth<br>(T)<br>(24") | Depth<br>(T)<br>(36") | EC-3<br>Type B | Depth<br>(T)<br>(18") | Depth<br>(T)<br>(24") | Depth<br>(T)<br>(36") |
|   |                | Class A1              | Class I               | Class II              |                | Class A1              | Class I               | Class II              |
|   | Sq. Yds.       | Cu. Yds.              | Cu. Yds.              | Cu. Yds.              | Sq. Yds.       | Cu. Yds.              | Cu. Yds.              | Cu. Yds.              |
| 3 x 3   | 22.46          | 11.23                 | 14.97                 | 22.46                 | 21.80          | 10.90                 | 14.53                 | 21.80                 |
| 3 x 4   | 30.65          | 15.32                 | 20.43                 | 30.65                 | 30.44          | 15.22                 | 20.29                 | 30.44                 |
| 4 x 3   | 30.11          | 15.05                 | 20.07                 | 30.11                 | 28.52          | 14.26                 | 19.01                 | 28.52                 |
| 4 x 4   | 40.05          | 20.03                 | 26.70                 | 40.05                 | 38.97          | 19.49                 | 25.98                 | 38.97                 |
| 4 x 5   | 50.96          | 25.48                 | 33.97                 | 50.96                 | 50.60          | 25.30                 | 33.73                 | 50.60                 |
| 4 x 6   | 62.64          | 31.32                 | 41.76                 | 62.64                 | 63.42          | 31.71                 | 42.28                 | 63.42                 |
| 5 x 3   | 38.51          | 19.25                 | 25.67                 | 38.51                 | 35.85          | 17.93                 | 23.90                 | 35.85                 |
| 5 x 4   | 50.01          | 25.01                 | 33.34                 | 50.01                 | 47.63          | 23.81                 | 31.75                 | 47.63                 |
| 5 x 5   | 62.57          | 31.28                 | 41.71                 | 62.57                 | 60.77          | 30.38                 | 40.51                 | 60.77                 |
| 5 x 6   | 75.95          | 37.97                 | 50.63                 | 75.95                 | 75.09          | 37.55                 | 50.06                 | 75.09                 |
| 5 x 7   | 90.33          | 45.17                 | 60.22                 | 90.33                 | 90.41          | 45.20                 | 60.27                 | 90.41                 |
| 6 x 4   | 60.86          | 30.43                 | 40.57                 | 60.86                 | 57.11          | 28.55                 | 38.07                 | 57.11                 |
| 6 x 5   | 74.94          | 37.47                 | 49.96                 | 74.94                 | 71.60          | 35.80                 | 47.73                 | 71.60                 |
| 6 x 6   | 90.03          | 45.02                 | 60.02                 | 90.03                 | 87.42          | 43.71                 | 58.28                 | 87.42                 |
| 6 x 7   | 104.73         | 52.37                 | 69.82                 | 104.73                | 104.27         | 52.13                 | 69.51                 | 104.27                |
| 6 x 8   | 122.67         | 61.34                 | 81.78                 | 122.67                | 122.37         | 61.19                 | 81.58                 | 122.37                |
| 7 x 4   | 72.39          | 36.20                 | 48.26                 | 72.39                 | 67.28          | 33.64                 | 44.85                 | 67.28                 |
| 7 x 6   | 104.90         | 52.45                 | 69.93                 | 104.90                | 100.37         | 50.18                 | 66.91                 | 100.37                |
| 7 x 8   | 141.17         | 70.58                 | 94.11                 | 141.17                | 138.36         | 69.18                 | 92.24                 | 138.36                |
| 7 x 10  | 180.48         | 90.24                 | 120.32                | 180.48                | 180.26         | 90.13                 | 120.17                | 180.26                |
| 8 x 4   | 84.72          | 42.36                 | 56.48                 | 84.72                 | 78.14          | 39.07                 | 52.09                 | 78.14                 |
| 8 x 6   | 120.54         | 60.27                 | 80.36                 | 120.54                | 114.00         | 57.00                 | 76.00                 | 114.00                |
| 8 x 8   | 160.23         | 80.12                 | 106.82                | 160.23                | 155.63         | 77.81                 | 103.75                | 155.63                |
| 8 x 10  | 203.22         | 101.61                | 135.48                | 203.22                | 189.74         | 94.87                 | 126.49                | 189.74                |
| 9 x 4   | 97.80          | 48.90                 | 65.20                 | 97.80                 | 89.64          | 44.82                 | 59.76                 | 89.64                 |
| 9 x 6   | 137.13         | 68.57                 | 91.42                 | 137.13                | 128.49         | 64.25                 | 85.66                 | 128.49                |
| 9 x 8   | 173.73         | 86.87                 | 115.82                | 173.73                | 172.73         | 86.36                 | 115.15                | 172.73                |
| 9 x 10  | 226.20         | 113.10                | 150.80                | 226.20                | 233.46         | 116.73                | 155.64                | 233.46                |
| 9 x 12  | 275.97         | 137.99                | 183.98                | 275.97                | 315.14         | 157.57                | 210.09                | 315.14                |
| 10 x 4  | 111.65         | 55.82                 | 74.43                 | 111.65                | 101.81         | 50.90                 | 67.87                 | 101.81                |
| 10 x 6  | 154.46         | 77.23                 | 102.97                | 154.46                | 143.64         | 71.82                 | 95.76                 | 143.64                |
| 10 x 8  | 200.07         | 100.04                | 133.38                | 200.07                | 190.59         | 95.30                 | 127.06                | 190.59                |
| 10 x 10   | 250.41         | 125.21                | 166.94                | 250.41                | 243.12         | 121.56                | 162.08                | 243.12                |
| 10 x 12   | 304.07         | 152.03                | 202.71                | 304.07                | 300.12         | 150.06                | 200.08                | 300.12                |
| 12 x 6  | 190.32         | 95.16                 | 126.88                | 190.32                | 176.52         | 88.26                 | 117.68                | 176.52                |
| 12 x 8  | 243.35         | 121.67                | 162.23                | 243.35                | 228.20         | 114.10                | 152.13                | 228.20                |
| 12 x 10   | 299.91         | 149.96                | 199.94                | 299.91                | 286.68         | 143.34                | 191.12                | 286.68                |
| 12 x 12   | 360.83         | 180.41                | 240.55                | 360.83                | 350.34         | 175.17                | 233.56                | 350.34                |

**TABLE D-19 CULVERT OUTLET PROTECTION FOR BOX CULVERT ST'D BCS-02 THRU BCS-50 (45° SKEW)**

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.\*

\* Rev. 7/10

| CULVERT<br>SIZE<br>(FEET)<br><br>SPAN X<br>RISE | 1 ½ : 1 Slope<br>No Skew |                       |                       |                       | 1 ½ : 1 Slope<br>15° Skew |                       |                       |                       |
|---|--------------------------|-----------------------|-----------------------|-----------------------|---------------------------|-----------------------|-----------------------|-----------------------|
|   | EC-3<br>Type B           | Depth<br>(T)<br>(18") | Depth<br>(T)<br>(24") | Depth<br>(T)<br>(36") | EC-3<br>Type B            | Depth<br>(T)<br>(18") | Depth<br>(T)<br>(24") | Depth<br>(T)<br>(36") |
|   |                          | Class A1              | Class I               | Class II              |                           | Class A1              | Class I               | Class II              |
|   | Sq. Yds.                 | Cu. Yds.              | Cu. Yds.              | Cu. Yds.              | Sq. Yds.                  | Cu. Yds.              | Cu. Yds.              | Cu. Yds.              |
| 3 x 3   | 5.84                     | 2.92                  | 3.89                  | 5.84                  | 5.97                      | 2.99                  | 3.98                  | 5.97                  |
| 3 x 4   | 7.29                     | 3.65                  | 4.86                  | 7.29                  | 7.47                      | 3.74                  | 4.98                  | 7.47                  |
| 4 x 3   | 8.22                     | 4.11                  | 5.48                  | 8.22                  | 8.40                      | 4.20                  | 5.60                  | 8.40                  |
| 4 x 4   | 9.78                     | 4.89                  | 6.52                  | 9.78                  | 10.01                     | 5.00                  | 6.67                  | 10.01                 |
| 4 x 5   | 11.34                    | 5.67                  | 7.56                  | 11.34                 | 11.61                     | 5.81                  | 7.74                  | 11.61                 |
| 4 x 6   | 12.89                    | 6.44                  | 8.59                  | 12.89                 | 13.22                     | 6.61                  | 8.81                  | 13.22                 |
| 5 x 3   | 11.22                    | 5.61                  | 7.48                  | 11.22                 | 11.42                     | 5.71                  | 7.61                  | 11.42                 |
| 5 x 4   | 13.10                    | 6.55                  | 8.73                  | 13.10                 | 13.38                     | 6.69                  | 8.92                  | 13.38                 |
| 5 x 5   | 15.00                    | 7.50                  | 10.00                 | 15.00                 | 15.33                     | 7.67                  | 10.22                 | 15.33                 |
| 5 x 6   | 16.89                    | 8.45                  | 11.26                 | 16.89                 | 17.30                     | 8.65                  | 11.53                 | 17.30                 |
| 5 x 7   | 18.78                    | 9.39                  | 12.52                 | 18.78                 | 19.23                     | 9.62                  | 12.82                 | 19.23                 |
| 6 x 4   | 16.89                    | 8.45                  | 11.26                 | 16.89                 | 17.21                     | 8.60                  | 11.47                 | 17.21                 |
| 6 x 5   | 19.23                    | 9.62                  | 12.82                 | 19.23                 | 19.62                     | 9.81                  | 13.08                 | 19.62                 |
| 6 x 6   | 21.69                    | 10.85                 | 14.46                 | 21.69                 | 22.16                     | 11.08                 | 14.77                 | 22.16                 |
| 6 x 7   | 24.15                    | 12.08                 | 16.10                 | 24.15                 | 24.69                     | 12.35                 | 16.46                 | 24.69                 |
| 6 x 8   | 25.77                    | 12.89                 | 17.18                 | 25.77                 | 26.40                     | 13.20                 | 17.60                 | 26.40                 |
| 7 x 4   | 21.11                    | 10.55                 | 14.07                 | 21.11                 | 21.47                     | 10.73                 | 14.31                 | 21.47                 |
| 7 x 6   | 26.40                    | 13.20                 | 17.60                 | 26.40                 | 26.94                     | 13.47                 | 17.96                 | 26.94                 |
| 7 x 8   | 31.98                    | 15.99                 | 21.32                 | 31.98                 | 32.70                     | 16.35                 | 21.80                 | 32.70                 |
| 7 x 10  | 37.56                    | 18.78                 | 25.04                 | 37.56                 | 38.46                     | 19.23                 | 25.64                 | 38.46                 |
| 8 x 4   | 25.77                    | 12.89                 | 17.18                 | 25.77                 | 26.19                     | 13.10                 | 17.46                 | 26.19                 |
| 8 x 6   | 31.55                    | 15.77                 | 21.03                 | 31.55                 | 32.18                     | 16.09                 | 21.45                 | 32.18                 |
| 8 x 8   | 37.32                    | 18.66                 | 24.88                 | 37.32                 | 38.15                     | 19.07                 | 25.43                 | 38.15                 |
| 8 x 10  | 43.11                    | 21.56                 | 28.74                 | 43.11                 | 44.13                     | 22.07                 | 29.42                 | 44.13                 |
| 9 x 4   | 30.90                    | 15.45                 | 20.60                 | 30.90                 | 31.35                     | 15.68                 | 20.90                 | 31.35                 |
| 9 x 6   | 37.34                    | 18.67                 | 24.89                 | 37.34                 | 38.03                     | 19.01                 | 25.35                 | 38.03                 |
| 9 x 8   | 43.76                    | 21.88                 | 29.17                 | 43.76                 | 44.69                     | 22.34                 | 29.79                 | 44.69                 |
| 9 x 10  | 51.00                    | 25.50                 | 34.00                 | 51.00                 | 52.13                     | 26.06                 | 34.75                 | 52.13                 |
| 9 x 12  | 57.92                    | 28.96                 | 38.61                 | 57.92                 | 59.28                     | 29.64                 | 39.52                 | 59.28                 |
| 10 x 4  | 36.44                    | 18.22                 | 24.29                 | 36.44                 | 36.95                     | 18.47                 | 24.63                 | 36.95                 |
| 10 x 6  | 43.56                    | 21.78                 | 29.04                 | 43.56                 | 44.31                     | 22.16                 | 29.54                 | 44.31                 |
| 10 x 8  | 50.67                    | 25.34                 | 33.78                 | 50.67                 | 51.68                     | 25.84                 | 34.45                 | 51.68                 |
| 10 x 10   | 57.77                    | 28.88                 | 38.51                 | 57.77                 | 59.03                     | 29.51                 | 39.35                 | 59.03                 |
| 10 x 12   | 64.88                    | 32.44                 | 43.25                 | 64.88                 | 66.39                     | 33.20                 | 44.26                 | 66.39                 |
| 12 x 6  | 57.33                    | 28.67                 | 38.22                 | 57.33                 | 58.22                     | 29.11                 | 38.81                 | 58.22                 |
| 12 x 8  | 65.78                    | 32.89                 | 43.85                 | 65.78                 | 66.96                     | 33.48                 | 44.64                 | 66.96                 |
| 12 x 10   | 74.22                    | 37.11                 | 49.48                 | 74.22                 | 75.71                     | 37.85                 | 50.47                 | 75.71                 |
| 12 x 12   | 82.67                    | 41.33                 | 55.11                 | 82.67                 | 84.45                     | 42.23                 | 56.30                 | 84.45                 |

**TABLE D-20 CULVERT OUTLET PROTECTION FOR MULTIPLE BOX CULVERT  
(INCREMENTS FOR EACH ADDITIONAL BARREL)**

Quantities To Be Used Only For Computations Of Dry Rip Rap For Outlet Protection.\*

\* Rev. 7/10



| CULVERT<br>SIZE<br>(FEET)<br><br>SPAN X<br>RISE | 2 : 1 Slope<br>30° Skew |                       |                       |                       | 2 : 1 Slope<br>45° Skew |                       |                       |                       |
|---|-------------------------|-----------------------|-----------------------|-----------------------|-------------------------|-----------------------|-----------------------|-----------------------|
|   | EC-3<br>Type B          | Depth<br>(T)<br>(18") | Depth<br>(T)<br>(24") | Depth<br>(T)<br>(36") | EC-3<br>Type B          | Depth<br>(T)<br>(18") | Depth<br>(T)<br>(24") | Depth<br>(T)<br>(36") |
|   |                         | Class A1              | Class I               | Class II              |                         | Class A1              | Class I               | Class II              |
|   | Sq. Yds.                | Cu. Yds.              | Cu. Yds.              | Cu. Yds.              | Sq. Yds.                | Cu. Yds.              | Cu. Yds.              | Cu. Yds.              |
| 3 x 3   | 6.45                    | 3.23                  | 4.30                  | 6.45                  | 7.41                    | 3.71                  | 4.94                  | 7.41                  |
| 3 x 4   | 7.83                    | 3.92                  | 5.22                  | 7.83                  | 9.42                    | 4.71                  | 6.28                  | 9.42                  |
| 4 x 3   | 8.94                    | 4.47                  | 5.96                  | 8.94                  | 10.16                   | 5.08                  | 6.77                  | 10.16                 |
| 4 x 4   | 10.74                   | 5.37                  | 7.16                  | 10.74                 | 12.36                   | 6.18                  | 8.24                  | 12.36                 |
| 4 x 5   | 12.54                   | 6.27                  | 8.36                  | 12.54                 | 14.57                   | 7.28                  | 9.71                  | 14.57                 |
| 4 x 6   | 14.34                   | 7.17                  | 9.56                  | 14.34                 | 16.76                   | 8.38                  | 11.17                 | 16.76                 |
| 5 x 3   | 12.09                   | 6.05                  | 8.06                  | 12.09                 | 13.56                   | 6.78                  | 9.04                  | 13.56                 |
| 5 x 4   | 14.28                   | 7.14                  | 9.52                  | 14.28                 | 16.23                   | 8.12                  | 10.82                 | 16.23                 |
| 5 x 5   | 16.46                   | 8.23                  | 10.97                 | 16.46                 | 18.92                   | 9.46                  | 12.61                 | 18.92                 |
| 5 x 6   | 18.65                   | 9.32                  | 12.43                 | 18.65                 | 21.59                   | 10.79                 | 14.39                 | 21.59                 |
| 5 x 7   | 20.82                   | 10.41                 | 13.88                 | 20.82                 | 24.24                   | 12.12                 | 16.16                 | 24.24                 |
| 6 x 4   | 18.27                   | 9.14                  | 12.18                 | 18.27                 | 20.57                   | 10.28                 | 13.71                 | 20.57                 |
| 6 x 5   | 20.99                   | 10.49                 | 13.99                 | 20.99                 | 23.87                   | 11.93                 | 15.91                 | 23.87                 |
| 6 x 6   | 23.75                   | 11.87                 | 15.83                 | 23.75                 | 27.21                   | 13.61                 | 18.14                 | 27.21                 |
| 6 x 7   | 26.73                   | 13.37                 | 17.82                 | 26.73                 | 30.74                   | 15.37                 | 20.49                 | 30.74                 |
| 6 x 8   | 28.53                   | 14.27                 | 19.02                 | 28.53                 | 33.14                   | 16.57                 | 22.09                 | 33.14                 |
| 7 x 4   | 22.68                   | 11.34                 | 15.12                 | 22.68                 | 25.34                   | 12.67                 | 16.89                 | 25.34                 |
| 7 x 6   | 28.76                   | 14.38                 | 19.17                 | 28.76                 | 32.75                   | 16.37                 | 21.83                 | 32.75                 |
| 7 x 8   | 35.30                   | 17.65                 | 23.53                 | 35.30                 | 40.61                   | 20.30                 | 27.07                 | 40.61                 |
| 7 x 10  | 41.79                   | 20.90                 | 27.86                 | 41.79                 | 48.44                   | 24.22                 | 32.29                 | 48.44                 |
| 8 x 4   | 27.57                   | 13.79                 | 18.38                 | 27.57                 | 30.57                   | 15.29                 | 20.38                 | 30.57                 |
| 8 x 6   | 34.25                   | 17.12                 | 22.83                 | 34.25                 | 38.23                   | 19.12                 | 25.82                 | 38.23                 |
| 8 x 8   | 40.91                   | 20.45                 | 27.27                 | 40.91                 | 46.91                   | 23.45                 | 31.27                 | 46.91                 |
| 8 x 10  | 47.58                   | 23.79                 | 31.72                 | 47.58                 | 55.23                   | 27.62                 | 36.82                 | 55.23                 |
| 9 x 4   | 32.90                   | 16.45                 | 21.93                 | 32.90                 | 36.23                   | 18.11                 | 24.15                 | 36.23                 |
| 9 x 6   | 40.34                   | 20.17                 | 26.89                 | 40.34                 | 45.33                   | 22.67                 | 30.22                 | 45.33                 |
| 9 x 8   | 48.00                   | 24.00                 | 32.00                 | 48.00                 | 54.69                   | 27.35                 | 36.46                 | 54.69                 |
| 9 x 10  | 56.18                   | 28.09                 | 37.45                 | 56.18                 | 64.55                   | 32.27                 | 43.03                 | 64.55                 |
| 9 x 12  | 64.22                   | 32.11                 | 42.81                 | 64.22                 | 74.24                   | 37.12                 | 49.49                 | 74.24                 |
| 10 x 4  | 38.64                   | 19.32                 | 25.76                 | 38.64                 | 42.33                   | 21.17                 | 28.22                 | 42.33                 |
| 10 x 6  | 46.85                   | 23.42                 | 31.23                 | 46.85                 | 52.40                   | 26.20                 | 34.93                 | 52.40                 |
| 10 x 8  | 55.07                   | 27.53                 | 36.71                 | 55.07                 | 62.45                   | 31.22                 | 41.63                 | 62.45                 |
| 10 x 10   | 63.27                   | 31.64                 | 42.18                 | 63.27                 | 72.51                   | 36.26                 | 48.34                 | 72.51                 |
| 10 x 12   | 71.49                   | 35.75                 | 47.66                 | 71.49                 | 82.56                   | 41.28                 | 55.04                 | 82.56                 |
| 12 x 6  | 61.25                   | 30.62                 | 40.83                 | 61.25                 | 67.83                   | 33.92                 | 45.22                 | 67.83                 |
| 12 x 8  | 71.01                   | 35.51                 | 47.34                 | 71.01                 | 79.77                   | 39.89                 | 53.18                 | 79.77                 |
| 12 x 10   | 80.76                   | 40.38                 | 53.84                 | 80.76                 | 91.71                   | 45.86                 | 61.14                 | 91.71                 |
| 12 x 12   | 90.51                   | 45.26                 | 60.34                 | 90.51                 | 103.65                  | 51.83                 | 69.10                 | 103.65                |

**TABLE D-21 CULVERT OUTLET PROTECTION FOR MULTIPLE BOX CULVERT  
(INCREMENTS FOR EACH ADDITIONAL BARREL)**

Quantities To Be Used Only For Computations Of Dry Rip Rap For Outlet Protection.\*

\* Rev. 7/10

PROJECT \_\_\_\_\_ STATION \_\_\_\_\_

If Line 5 is over 5' 4", use Type A Tower  
 If Line 5 is 3' 2" to 5' 4", use Type B Tower  
 If Line 5 is 2' 4" to 3' 2", use Type C Tower

Increase above dimensions by 1" for use with 72" pipe.

1. Grade Elevation \_\_\_\_\_  
 2. Minus Inv. Elev. \_\_\_\_\_  
 3. Vertical Difference \_\_\_\_\_  
 4. Minus Pipe Size \_\_\_\_\_  
 5. Difference \_\_\_\_\_

CHAMBER

6. Type \_\_\_\_\_ Pipe Size \_\_\_\_\_ Turn Angle \_\_\_\_\_

Less: Pipe Openings

7. Size \_\_\_\_\_ Class \_\_\_\_\_ Defl. Angle \_\_\_\_\_  
 8. Size \_\_\_\_\_ Class \_\_\_\_\_ Defl. Angle \_\_\_\_\_  
 9. Size \_\_\_\_\_ Class \_\_\_\_\_ Defl. Angle \_\_\_\_\_  
 10. Size \_\_\_\_\_ Class \_\_\_\_\_ Defl. Angle \_\_\_\_\_

11. Total Deductions (Lines 7-10) \_\_\_\_\_

12. Quantities for Chamber  
 (Subtract Line 11 from Line 6 and Transfer to Line 17)

TOWER

13. Type \_\_\_\_\_ x Height \_\_\_\_\_ Min. Height \_\_\_\_\_  
 x 48" Pipe - Line 3 minus 6.83'  
 x 54" Pipe - Line 3 minus 6.83'  
 x 60" Pipe - Line 3 minus 7.33'  
 x 66" Pipe - Line 3 minus 7.83'  
 x 72" Pipe - Line 3 minus 9.33'

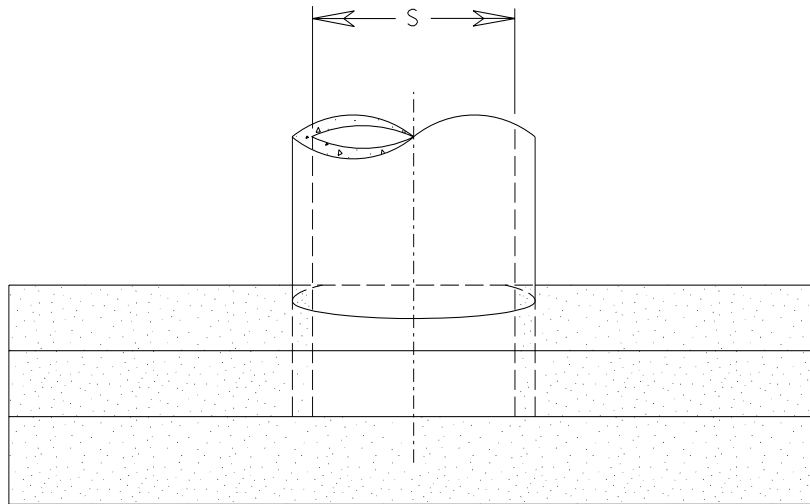
14. Minimum Height Quantities \_\_\_\_\_  
 15. (Line 13 less Min. Height) x increment per foot \_\_\_\_\_  
 16. Quantities for tower (Add Lines 14 & 15) \_\_\_\_\_  
 17. Quantities for Chamber (Line 12) \_\_\_\_\_  
 18. Total Concrete and Reinforcing Steel (Add Lines 16 & 17) \_\_\_\_\_

CONCRETE CU. YDS. \_\_\_\_\_  
 REINFORCING STEEL LBS. \_\_\_\_\_

STRUCTURAL STEEL QUANTITY (Lbs.) \_\_\_\_\_

| PIPE SIZE | PIPE CLASS             | CONCRETE                |                         |                         |                         | REINFORCING STEEL LBS.     |
|-----------|------------------------|-------------------------|-------------------------|-------------------------|-------------------------|----------------------------|
|           |                        | 0°<br>CU. YDS.          | 15°<br>CU. YDS.         | 30°<br>CU. YDS.         | 45°<br>CU. YDS.         |                            |
| 12"       | III, IV, V<br>C. M.    | 0.035<br>0.019          | 0.036<br>0.020          | 0.040<br>0.022          | 0.050<br>0.027          | 17.67<br>11.06             |
| 15"       | III, IV, V<br>C. M.    | 0.050<br>0.030          | 0.052<br>0.031          | 0.058<br>0.034          | 0.071<br>0.042          | 24.88<br>15.93             |
| 18"       | III, IV, V<br>C. M.    | 0.069<br>0.043          | 0.072<br>0.044          | 0.080<br>0.049          | 0.099<br>0.061          | 33.23<br>21.68             |
| 24"       | III, IV, V<br>C. M.    | 0.118<br>0.076          | 0.122<br>0.078          | 0.137<br>0.087          | 0.168<br>0.108          | 53.53<br>35.33             |
| 30"       | III, IV, V<br>C. M.    | 0.179<br>0.118          | 0.186<br>0.122          | 0.209<br>0.137          | 0.256<br>0.168          | 78.64<br>53.53             |
| 36"       | III, IV, V<br>C. M.    | 0.254<br>0.170          | 0.263<br>0.176          | 0.294<br>0.197          | 0.362<br>0.242          | 108.76<br>74.76            |
| 42"       | III, IV, V<br>C. M.    | 0.341<br>0.231          | 0.353<br>0.240          | 0.395<br>0.268          | 0.486<br>0.330          | 143.33<br>99.53            |
| 48"       | III, IV, V<br>C. M.    | 0.441<br>0.302          | 0.457<br>0.313          | 0.511<br>0.350          | 0.629<br>0.431          | 182.90<br>127.85           |
| 54"       | III & IV<br>V<br>C. M. | 0.554<br>0.580<br>0.382 | 0.574<br>0.600<br>0.422 | 0.642<br>0.672<br>0.443 | 0.789<br>0.826<br>0.545 | 227.29<br>257.42<br>159.70 |
| 60"       | III & IV<br>V<br>C. M. | 0.679<br>0.708<br>0.472 | 0.704<br>0.734<br>0.481 | 0.787<br>0.821<br>0.551 | 0.965<br>1.009<br>0.673 | 276.49<br>287.65<br>195.09 |
| 66"       | III & IV<br>V<br>C. M. | 0.818<br>0.849<br>0.571 | 0.847<br>0.880<br>0.591 | 0.948<br>0.985<br>0.682 | 1.166<br>1.211<br>0.814 | 330.50<br>342.70<br>234.02 |
| 72"       | III & IV<br>V<br>C. M. | 0.969<br>1.003<br>0.679 | 1.004<br>1.040<br>0.704 | 1.123<br>1.163<br>0.787 | 1.382<br>1.431<br>0.969 | 389.34<br>402.58<br>276.49 |

FIGURE D-1 COMPUTATIONS FOR STANDARD JB-1 JUNCTION BOX  
 TABLE D-22 ADJUSTMENT QUANTITIES FOR JUNCTION BOX



**PLAN VIEW**



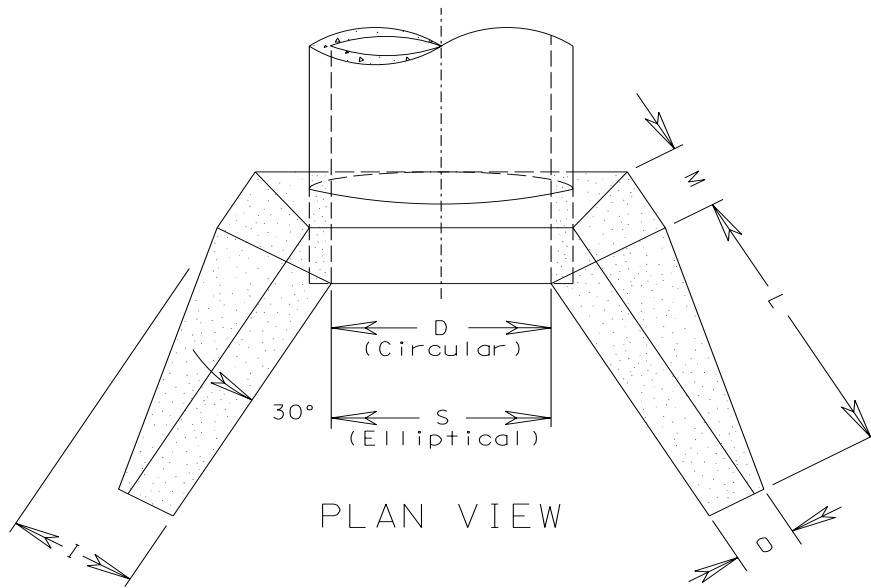
Area for computing ratio

| STANDARD | (S)<br>Span of Culvert<br>(inches) | Area (A)                 |
|----------|------------------------------------|--------------------------|
|          |                                    | Conc or C. M.<br>Sq. Ft. |
| EW-1A    | 49                                 | 24.40                    |
|          | 53                                 | 27.06                    |

Area is given for one endwall.  
Double area shown if two endwalls are used.

|                       |   |
|-----------------------|---|
| TO DETERMINE<br>RATIO | $\frac{A}{S \text{ (in feet)} \times \text{Length of Culvert}}$ |
|-----------------------|---|

**TABLE D-23 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION  
STANDARD EW-1A**



Area for computing ratio

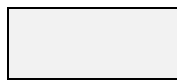
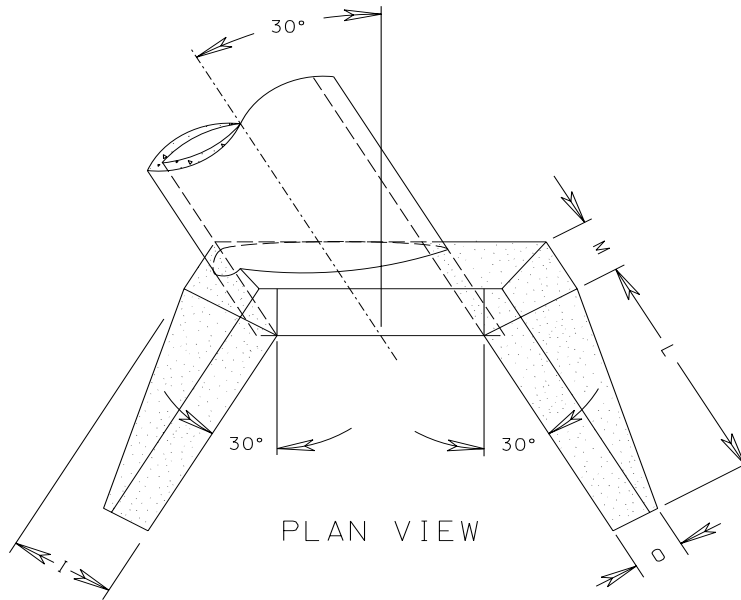
| (D)<br>Diameter of<br>Culvert<br>(inches) | Area (A)         |                |
|---|------------------|----------------|
|   | 1 ½ : 1<br>Slope | 2 : 1<br>Slope |
|   | Sq. Ft.          | Sq. Ft.        |
| 48  | 27.31            | 33.95          |
| 54  | 33.43            | 41.64          |
| 60  | 40.07            | 50.05          |
| 66  | 47.38            | 59.29          |
| 72  | 55.29            | 69.25          |
| 78  | 63.74            | 80.00          |
| 84  | 72.80            | 91.55          |

| (S)<br>Span of<br>Culvert<br>(inches) | Area (A)         |                |
|---------------------------------------|------------------|----------------|
|                                       | 1 ½ : 1<br>Slope | 2 : 1<br>Slope |
|                                       | Sq. Ft.          | Sq. Ft.        |
| 60                                    | 23.31            | 28.88          |
| 68                                    | 23.31            | 28.88          |
| 76                                    | 27.31            | 33.95          |
| 83                                    | 33.43            | 41.64          |
| 91                                    | 40.07            | 50.05          |
| 98                                    | 47.38            | 59.29          |
| 106                                   | 55.29            | 69.25          |

Area is given for one endwall.  
Double area shown if two endwalls are used.

|                       |   |
|-----------------------|---|
| TO DETERMINE<br>RATIO | $\frac{A}{D \text{ or } S \text{ (in feet)} \times \text{Length of Culvert}}$ |
|-----------------------|---|

**TABLE D-24 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARDS EW-2, EW-2A**



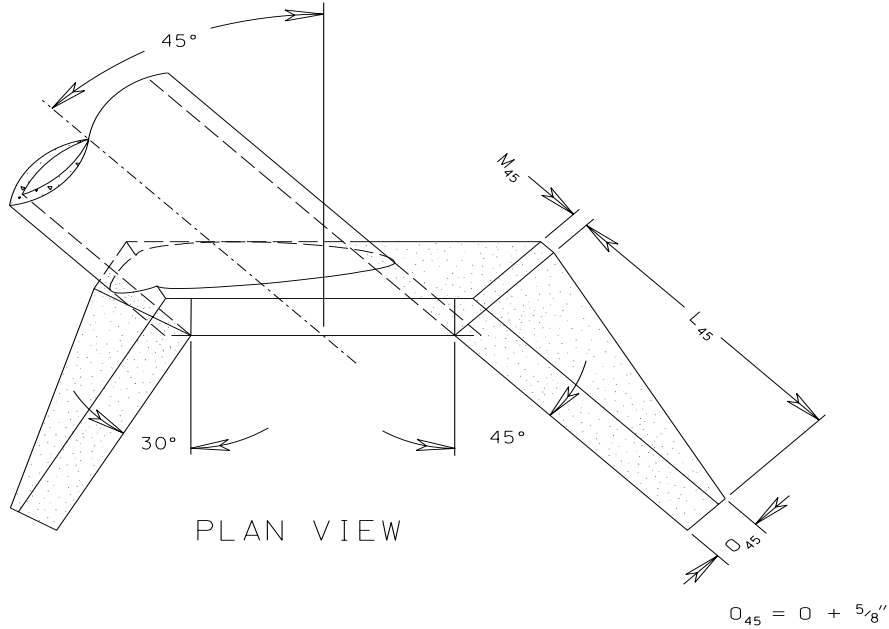
Area for computing ratio

| (D)<br>Diameter of<br>Culvert<br>(inches) | Area (A)         |                |
|---|------------------|----------------|
|   | 1 ½ : 1<br>Slope | 2 : 1<br>Slope |
|   | Sq. Ft.          | Sq. Ft.        |
| 48  | 27.31            | 33.95          |
| 54  | 33.43            | 41.64          |
| 60  | 40.07            | 50.05          |
| 66  | 47.38            | 59.29          |
| 72  | 55.29            | 69.25          |
| 78  | 63.74            | 80.00          |
| 84  | 72.80            | 91.55          |

Area is given for one endwall.  
Double area shown if two endwalls are used.

|                       |   |
|-----------------------|---|
| TO DETERMINE<br>RATIO | $\frac{A}{D \text{ (in feet)} \times \text{Length of Culvert}}$ |
|-----------------------|---|

**TABLE D-25 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION  
STANDARD EW-2S (30°)**



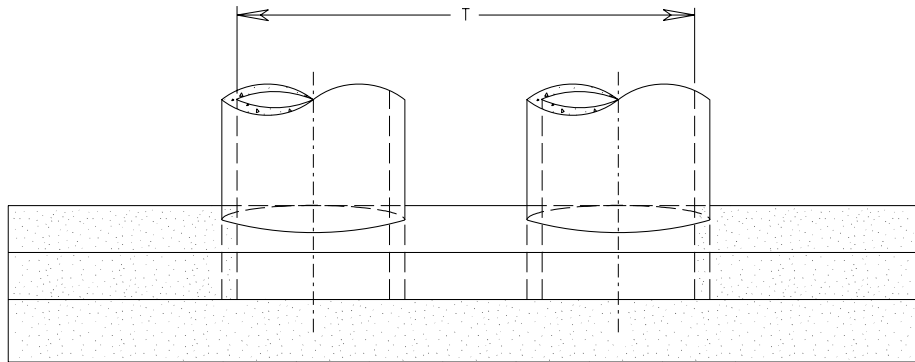
Area for computing ratio

| (D)<br>Diameter of<br>Culvert<br>(inches) | Area (A)                    |                           |
|---|-----------------------------|---------------------------|
|   | 1 ½ : 1<br>Slope<br>Sq. Ft. | 2 : 1<br>Slope<br>Sq. Ft. |
| 48  | 32.23                       | 40.50                     |
| 54  | 39.37                       | 49.45                     |
| 60  | 47.31                       | 59.51                     |
| 66  | 55.90                       | 70.43                     |
| 72  | 65.20                       | 82.30                     |
| 78  | 75.25                       | 95.11                     |
| 84  | 85.96                       | 108.84                    |

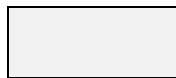
Area is given for one endwall.  
Double area shown if two endwalls are used.

|                       |   |
|-----------------------|---|
| TO DETERMINE<br>RATIO | $\frac{A}{D \text{ (in feet)} \times \text{Length of Culvert}}$ |
|-----------------------|---|

**TABLE D-26 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION  
STANDARD EW-2S (45°)**



**PLAN VIEW**



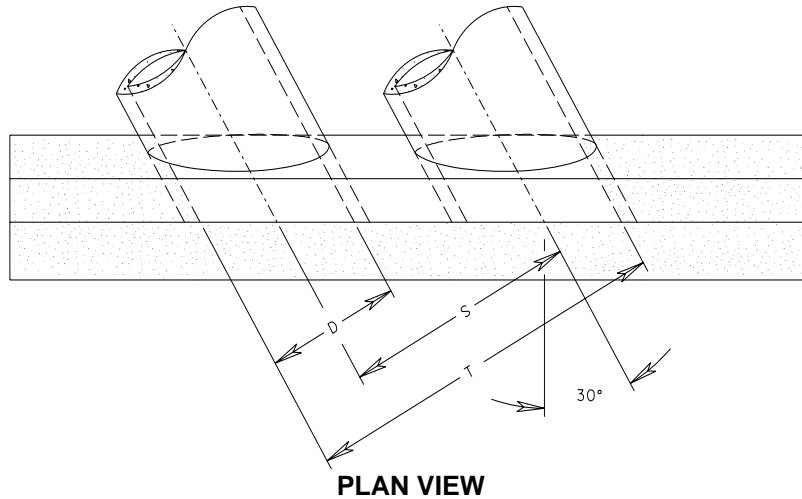
Area for computing ratio

| (D)<br>Diameter of<br>Culvert<br>(inches) | Area (A)          |         |             |         |                |         |
|---|-------------------|---------|-------------|---------|----------------|---------|
|   | Double Line       |         | Triple Line |         | Quadruple Line |         |
|   | Conc.             | C.M.    | Conc.       | C.M.    | Conc.          | C.M.    |
|   | Sq. Ft.           | Sq. Ft. | Sq. Ft.     | Sq. Ft. | Sq. Ft.        | Sq. Ft. |
| 15  |                   |         | 8.18        | 8.52    | 9.94           | 9.50    |
| 18  | 9.96              | 9.79    | 11.29       | 10.96   | 12.63          | 12.13   |
| 24  | 16.67             | 16.39   | 19.00       | 18.44   | 21.33          | 20.50   |
| 30  | 23.88             | 23.50   | 27.13       | 26.38   | 30.38          | 29.25   |
| 36  | 30.88             | 30.44   | 34.75       | 33.88   | 38.63          | 37.31   |
|   | Culvert Width (T) |         |             |         |                |         |
|   | Feet              | Feet    | Feet        | Feet    | Feet           | Feet    |
| 15  |                   |         | 5.75        | 5.17    | 8.00           | 7.13    |
| 18  | 4.17              | 3.83    | 6.83        | 6.17    | 9.50           | 8.50    |
| 24  | 5.50              | 5.08    | 9.00        | 8.17    | 12.50          | 11.25   |
| 30  | 6.83              | 6.33    | 11.17       | 10.17   | 15.50          | 14.00   |
| 36  | 8.17              | 7.58    | 13.33       | 12.17   | 18.50          | 16.75   |

Area is given for one endwall.  
Double area shown if two endwalls are used.

|                       |   |
|-----------------------|---|
| TO DETERMINE<br>RATIO | $\frac{A}{T \text{ (in feet)} \times \text{Length of Culvert}}$ |
|-----------------------|---|

**TABLE D-27 COMPUTATION OF RATIOS FOR MINOR STRUCTURE  
EXCAVATION STANDARD EW-6**



Area for computing ratio

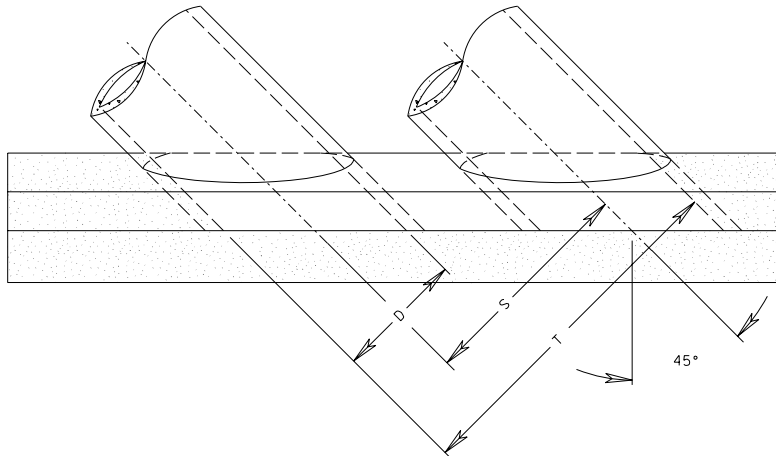
| (D)<br>Diameter of<br>Culvert<br>(inches) | Area (A)          |         |             |         |                |         |
|---|-------------------|---------|-------------|---------|----------------|---------|
|   | Double Line       |         | Triple Line |         | Quadruple Line |         |
|   | Conc.             | C.M.    | Conc.       | C.M.    | Conc.          | C.M.    |
|   | Sq. Ft.           | Sq. Ft. | Sq. Ft.     | Sq. Ft. | Sq. Ft.        | Sq. Ft. |
| 15  |                   |         | 8.94        | 8.61    | 10.23          | 9.74    |
| 18  | 9.88              | 9.69    | 11.43       | 11.04   | 12.98          | 12.40   |
| 24  | 16.56             | 16.25   | 19.26       | 18.63   | 21.95          | 21.00   |
| 30  | 23.69             | 23.27   | 27.44       | 26.59   | 31.18          | 29.91   |
| 36  | 30.44             | 30.04   | 34.81       | 34.01   | 39.17          | 37.97   |
|   | Culvert Width (T) |         |             |         |                |         |
|   | Feet              | Feet    | Feet        | Feet    | Feet           | Feet    |
| 15  |                   |         | 5.75        | 5.17    | 8.00           | 7.13    |
| 18  | 4.17              | 3.83    | 6.83        | 6.17    | 9.50           | 8.50    |
| 24  | 5.50              | 5.08    | 9.00        | 8.17    | 12.50          | 11.25   |
| 30  | 6.83              | 6.33    | 11.17       | 10.17   | 15.50          | 14.00   |
| 36  | 8.17              | 7.58    | 13.33       | 12.17   | 18.50          | 16.75   |

Area is given for one endwall.  
Double area shown if two endwalls are used.

|                       |   |
|-----------------------|---|
| TO DETERMINE<br>RATIO | $\frac{A}{T \text{ (in feet)} \times \text{Length of Culvert}}$ |
|-----------------------|---|

**TABLE D-28 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD EW-6S (30°)**





**PLAN VIEW**



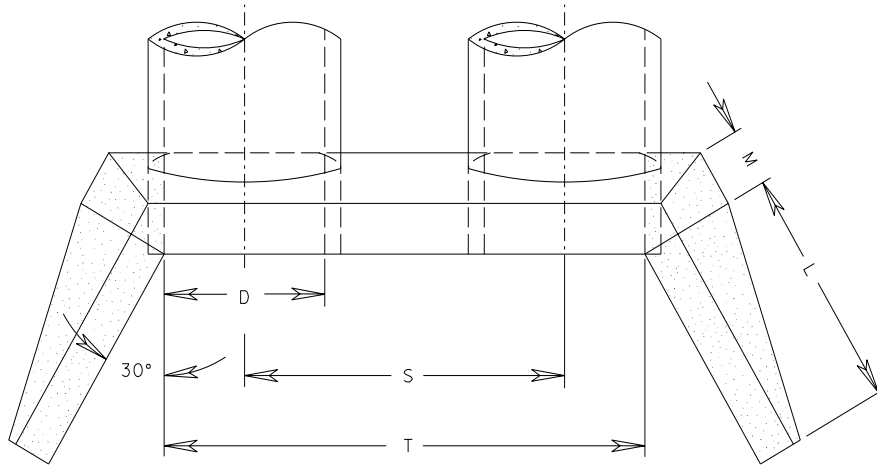
Area for computing ratio

| (D)<br>Diameter of<br>Culvert<br>(inches) | Area (A)          |         |             |         |                |         |
|---|-------------------|---------|-------------|---------|----------------|---------|
|   | Double Line       |         | Triple Line |         | Quadruple Line |         |
|   | Conc.             | C.M.    | Conc.       | C.M.    | Conc.          | C.M.    |
|   | Sq. Ft.           | Sq. Ft. | Sq. Ft.     | Sq. Ft. | Sq. Ft.        | Sq. Ft. |
| 15  |                   |         | 9.17        | 8.78    | 10.75          | 10.16   |
| 18  | 9.73              | 9.50    | 11.62       | 11.16   | 13.50          | 12.81   |
| 24  | 16.39             | 16.01   | 19.68       | 18.92   | 22.98          | 21.84   |
| 30  | 23.40             | 22.87   | 27.99       | 26.92   | 32.58          | 30.98   |
| 36  | 29.98             | 29.37   | 35.45       | 34.22   | 40.92          | 39.08   |
|   | Culvert Width (T) |         |             |         |                |         |
|   | Feet              | Feet    | Feet        | Feet    | Feet           | Feet    |
| 15  |                   |         | 5.75        | 5.17    | 8.00           | 7.13    |
| 18  | 4.17              | 3.83    | 6.83        | 6.17    | 9.50           | 8.50    |
| 24  | 5.50              | 5.08    | 9.00        | 8.17    | 12.50          | 11.25   |
| 30  | 6.83              | 6.33    | 11.17       | 10.17   | 15.50          | 14.00   |
| 36  | 8.17              | 7.58    | 13.33       | 12.17   | 18.50          | 16.75   |

Area is given for one endwall.  
Double area shown if two endwalls are used.

|                       |   |
|-----------------------|---|
| TO DETERMINE<br>RATIO | $\frac{A}{T \text{ (in feet)} \times \text{Length of Culvert}}$ |
|-----------------------|---|

**TABLE D-29 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD EW-6S (45°)**



**PLAN VIEW**



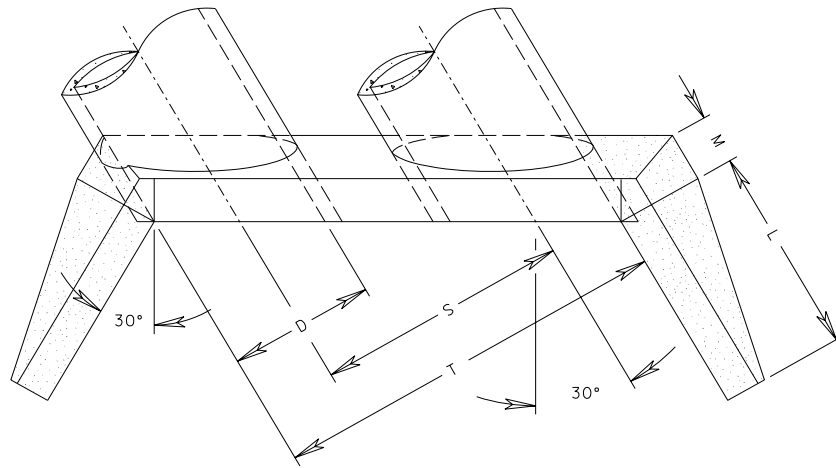
Area for computing ratio

| (D)<br>Diameter of<br>Culvert<br>(inches) | Area (A)                    |                           | Culvert width (T) |              |               |              |                |              |
|---|-----------------------------|---------------------------|-------------------|--------------|---------------|--------------|----------------|--------------|
|   | 1 ½ : 1<br>Slope<br>Sq. Ft. | 2 : 1<br>Slope<br>Sq. Ft. | Double Line       |              | Triple Line   |              | Quadruple Line |              |
|   |                             |                           | Conc.<br>Feet     | C.M.<br>Feet | Conc.<br>Feet | C.M.<br>Feet | Conc.<br>Feet  | C.M.<br>Feet |
| 42  | 23.31                       | 28.88                     | 9.50              | 8.79         | 15.50         | 14.08        | 21.50          | 19.37        |
| 48  | 27.31                       | 33.95                     | 10.83             | 10.04        | 17.67         | 16.08        | 24.50          | 22.12        |
| 54  | 33.43                       | 41.64                     | 12.17             | 11.29        | 19.83         | 18.08        | 27.50          | 24.87        |
| 60  | 40.07                       | 50.05                     | 13.50             | 12.54        | 22.00         | 20.08        | 30.50          | 27.62        |
| 66  | 47.38                       | 59.29                     | 14.83             | 13.79        | 24.17         | 22.08        | 33.50          | 30.37        |
| 72  | 55.29                       | 69.25                     | 16.17             | 15.04        | 26.33         | 24.08        | 36.50          | 33.12        |
| 78  | 63.74                       | 80.00                     | 17.50             | 16.29        | 28.50         | 26.08        | 39.50          | 35.87        |
| 84  | 72.80                       | 91.55                     | 18.83             | 17.54        | 30.67         | 28.08        | 42.50          | 38.62        |

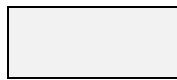
Area is given for one endwall.  
Double area shown if two endwalls are used.

|                       |   |
|-----------------------|---|
| TO DETERMINE<br>RATIO | $\frac{A}{T \text{ (in feet)} \times \text{Length of Culvert}}$ |
|-----------------------|---|

**TABLE D-30 COMPUTATION OF RATIOS FOR MINOR STRUCTURE  
EXCAVATION STANDARD EW-7S**



**PLAN VIEW**



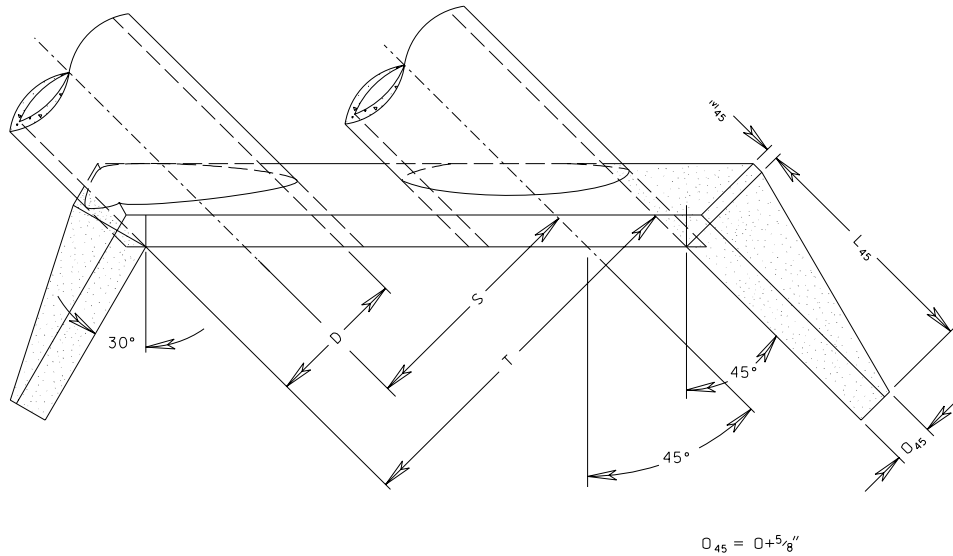
Area for computing ratio

| (D)<br>Diameter of<br>Culvert<br>(inches) | Area (A)                    |                           | Culvert width (T) |              |               |              |                |              |
|---|-----------------------------|---------------------------|-------------------|--------------|---------------|--------------|----------------|--------------|
|   | 1 ½ : 1<br>Slope<br>Sq. Ft. | 2 : 1<br>Slope<br>Sq. Ft. | Double Line       |              | Triple Line   |              | Quadruple Line |              |
|   |                             |                           | Conc.<br>Feet     | C.M.<br>Feet | Conc.<br>Feet | C.M.<br>Feet | Conc.<br>Feet  | C.M.<br>Feet |
| 42  | 23.31                       | 28.88                     | 9.50              | 8.79         | 15.50         | 14.08        | 21.50          | 19.37        |
| 48  | 27.31                       | 33.95                     | 10.83             | 10.04        | 17.67         | 16.08        | 24.50          | 22.12        |
| 54  | 33.43                       | 41.64                     | 12.17             | 11.29        | 19.83         | 18.08        | 27.50          | 24.87        |
| 60  | 40.07                       | 50.05                     | 13.50             | 12.54        | 22.00         | 20.08        | 30.50          | 27.62        |
| 66  | 47.38                       | 59.29                     | 14.83             | 13.79        | 24.17         | 22.08        | 33.50          | 30.37        |
| 72  | 55.29                       | 69.25                     | 16.17             | 15.04        | 26.33         | 24.08        | 36.50          | 33.12        |
| 78  | 63.74                       | 80.00                     | 17.50             | 16.29        | 28.50         | 26.08        | 39.50          | 35.87        |
| 84  | 72.80                       | 91.55                     | 18.83             | 17.54        | 30.67         | 28.08        | 42.50          | 38.62        |

Area is given for one endwall.  
Double area shown if two endwalls are used.

|                       |   |
|-----------------------|---|
| TO DETERMINE<br>RATIO | $\frac{A}{T \text{ (in feet)} \times \text{Length of Culvert}}$ |
|-----------------------|---|

**TABLE D-31 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD EW-7S (30°)**



**PLAN VIEW**



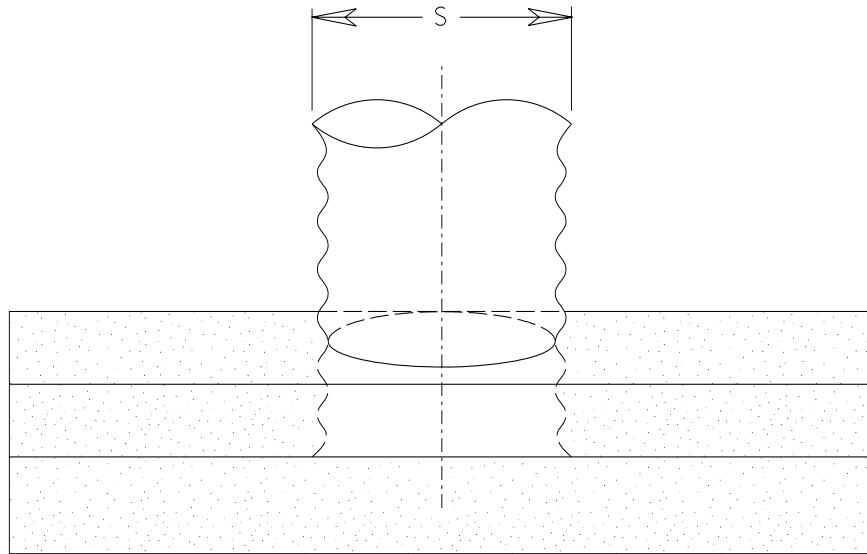
Area for computing ratio

| (D)<br>Diameter of<br>Culvert<br>(inches) | Area (A)         |                | Culvert width (T) |              |               |              |                |              |
|---|------------------|----------------|-------------------|--------------|---------------|--------------|----------------|--------------|
|   | 1 ½ : 1<br>Slope | 2 : 1<br>Slope | Double Line       |              | Triple Line   |              | Quadruple Line |              |
|   | Sq. Ft.          | Sq. Ft.        | Conc.<br>Feet     | C.M.<br>Feet | Conc.<br>Feet | C.M.<br>Feet | Conc.<br>Feet  | C.M.<br>Feet |
| 42  | 27.37            | 34.10          | 9.50              | 8.79         | 15.50         | 14.08        | 21.50          | 19.37        |
| 48  | 32.23            | 40.50          | 10.83             | 10.04        | 17.67         | 16.08        | 24.50          | 22.12        |
| 54  | 39.37            | 49.45          | 12.17             | 11.29        | 19.83         | 18.08        | 27.50          | 24.87        |
| 60  | 47.31            | 59.51          | 13.50             | 12.54        | 22.00         | 20.08        | 30.50          | 27.62        |
| 66  | 55.90            | 70.43          | 14.83             | 13.79        | 24.17         | 22.08        | 33.50          | 30.37        |
| 72  | 65.20            | 82.30          | 16.17             | 15.04        | 26.33         | 24.08        | 36.50          | 33.12        |
| 78  | 75.25            | 95.11          | 17.50             | 16.29        | 28.50         | 26.08        | 39.50          | 35.87        |
| 84  | 85.96            | 108.84         | 18.83             | 17.54        | 30.67         | 28.08        | 42.50          | 38.62        |

Area is given for one endwall.  
Double area shown if two endwalls are used.

|                       |   |
|-----------------------|---|
| TO DETERMINE<br>RATIO | $\frac{A}{T \text{ (in feet)} \times \text{Length of Culvert}}$ |
|-----------------------|---|

**TABLE D-32 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION  
STANDARD EW-7S (45°)**



**PLAN VIEW**



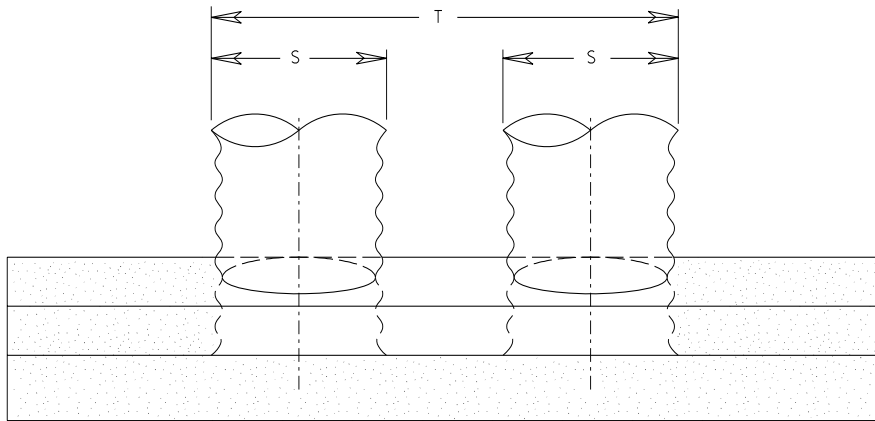
Area for computing ratio

| (S)<br>Span of Culvert<br>(inches) | Area (A) |
|------------------------------------|----------|
|                                    | Sq. Ft.  |
| 49                                 | 22.65    |
| *46                                | 23.08    |
| 57                                 | 28.54    |
| *53                                | 29.21    |

Area is given for one endwall.  
 Double area shown if two endwalls are used  
 \* 3"x1" corrugation dimension.

|                       |   |
|-----------------------|---|
| TO DETERMINE<br>RATIO | $\frac{A}{S \text{ (in feet)} \times \text{Length of Culvert}}$ |
|-----------------------|---|

**TABLE D-33 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION  
 STANDARD EW-9**



**PLAN VIEW**



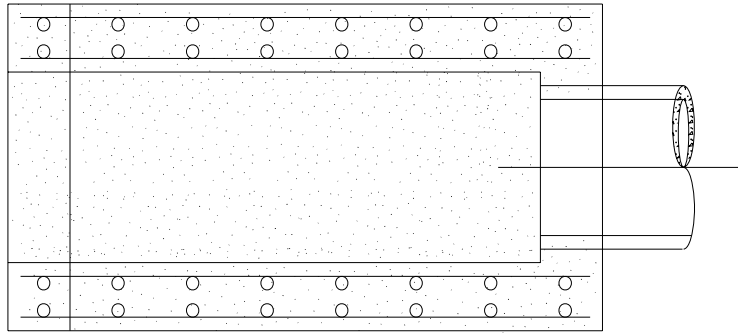
Area for computing ratio

| (S)<br>Span of<br>Culvert<br>(inches) | Area (A)       |                |                | Culvert Width (T) |                |                   |
|---------------------------------------|----------------|----------------|----------------|-------------------|----------------|-------------------|
|                                       | Double<br>Line | Triple<br>Line | Quadruple Line | Double<br>Line    | Triple<br>Line | Quadruple<br>Line |
|                                       | Sq. Ft.        | Sq. Ft         | Sq. Ft         | Feet              | Feet           | Feet              |
| 21                                    | 6.47           | 7.65           | 8.83           | 4.58              | 7.42           | 10.25             |
| 24                                    | 8.93           | 10.34          | 11.75          | 5.08              | 8.17           | 11.25             |
| 28                                    | 11.04          | 12.75          | 14.46          | 5.75              | 9.17           | 12.58             |
| 35                                    | 16.71          | 19.38          | 22.04          | 6.92              | 10.92          | 14.92             |
| 42                                    | 23.33          | 26.96          | 30.58          | 8.33              | 13.17          | 18.00             |
| *40                                   | 23.63          | 27.25          | 30.88          | 8.17              | 13.00          | 17.83             |
| 49                                    | 27.04          | 31.23          | 35.42          | 9.67              | 15.25          | 20.83             |
| *46                                   | 27.48          | 31.67          | 35.85          | 9.42              | 15.00          | 20.58             |
| 57                                    | 33.42          | 38.29          | 43.17          | 11.25             | 17.75          | 24.25             |
| *53                                   | 34.08          | 38.96          | 43.83          | 10.92             | 17.42          | 23.92             |
|                                       |                |                |                |                   |                |                   |

Area is given for one endwall.  
 Double area shown if two endwalls are used  
 \* 3"x1" corrugation dimension.

|                       |   |
|-----------------------|---|
| TO DETERMINE<br>RATIO | $\frac{A}{T \text{ (in feet)} \times \text{Length of Culvert}}$ |
|-----------------------|---|

**TABLE D-34 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION  
 STANDARD EW-10**



**PLAN VIEW**

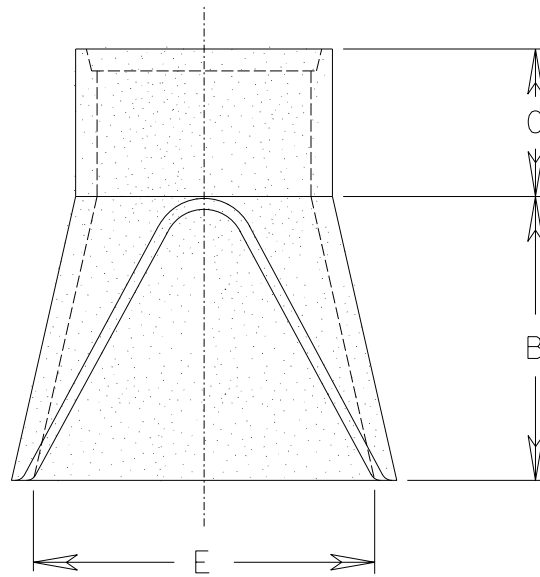


Area for computing ratio

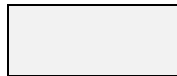
| (D)<br>Diameter of<br>Culvert<br>(inches) | Area (A)     |              |              |
|---|--------------|--------------|--------------|
|   | 3:1<br>Slope | 4:1<br>Slope | 6:1<br>Slope |
|   | Sq. Ft       | Sq. Ft.      | Sq. Ft       |
| 48  | 114.42       | 150.00       | 221.17       |
| 54  | 143.83       | 188.83       | 278.83       |
| 60  | 156.33       | 205.67       | 304.33       |

|                       |   |
|-----------------------|---|
| TO DETERMINE<br>RATIO | $\frac{A}{D \text{ (in feet)} \times \text{Length of Culvert}}$ |
|-----------------------|---|

**TABLE D-35 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION  
STANDARD EW-11**



**PLAN VIEW**



Area for computing ratio

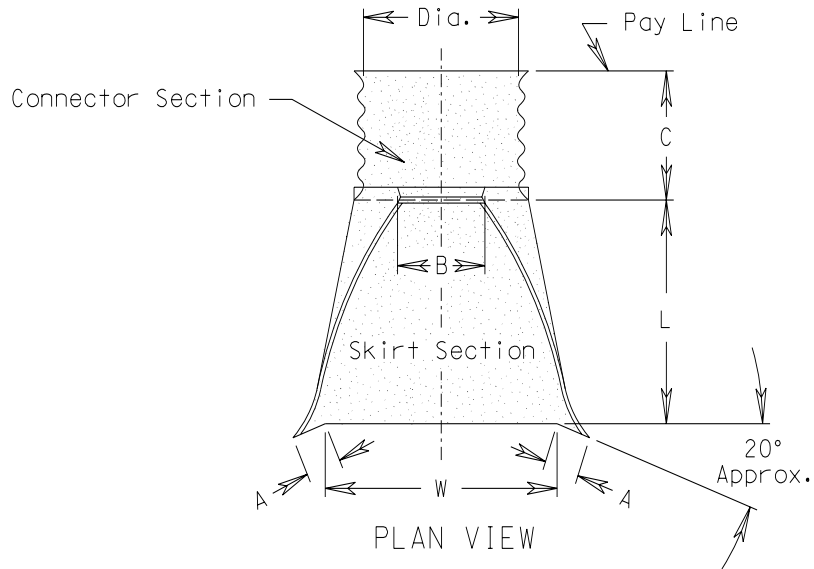
| (D)<br>Diameter of<br>Culvert<br>(inches) | Area (A) |
|---|----------|
|   | Sq. Ft.  |
| 48  | 48.47    |
| 54  | 52.47    |
| 60  | 57.00    |

Area is given for one endwall.  
Double area shown if two endsections are used

|                       |   |
|-----------------------|---|
| TO DETERMINE<br>RATIO | $\frac{A}{D \text{ (in feet)} \times \text{Length of Culvert}}$ |
|-----------------------|---|

**TABLE D-36 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION  
STANDARD ES-1**





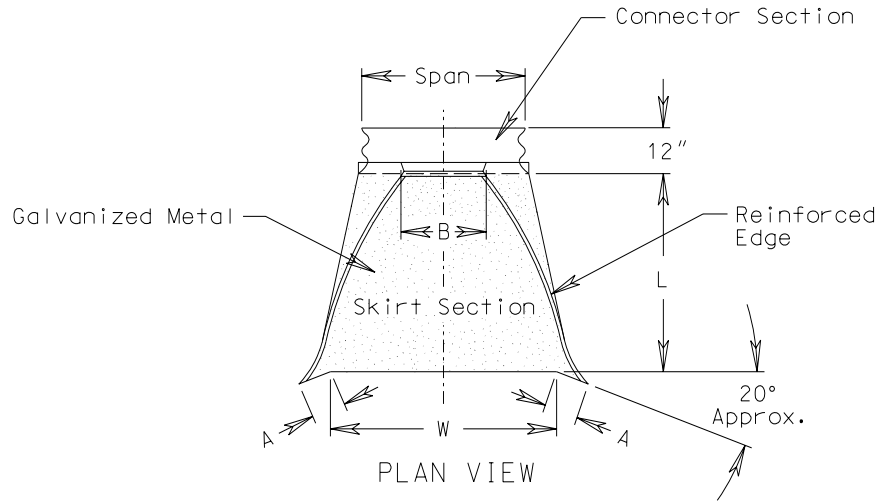
Area for computing ratio

| (D)<br>Diameter of<br>Culvert<br>(inches) | Area (A) |
|---|----------|
|   | Sq. Ft.  |
| 48  | 53.64    |
| 54  | 67.84    |
| 60  | 76.63    |

Area is given for one endwall.  
Double area shown if two endsections are used

|                       |   |
|-----------------------|---|
| TO DETERMINE<br>RATIO | $\frac{A}{D \text{ (in feet)} \times \text{Length of Culvert}}$ |
|-----------------------|---|

**TABLE D-37 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION  
STANDARD ES-2**



Area for computing ratio

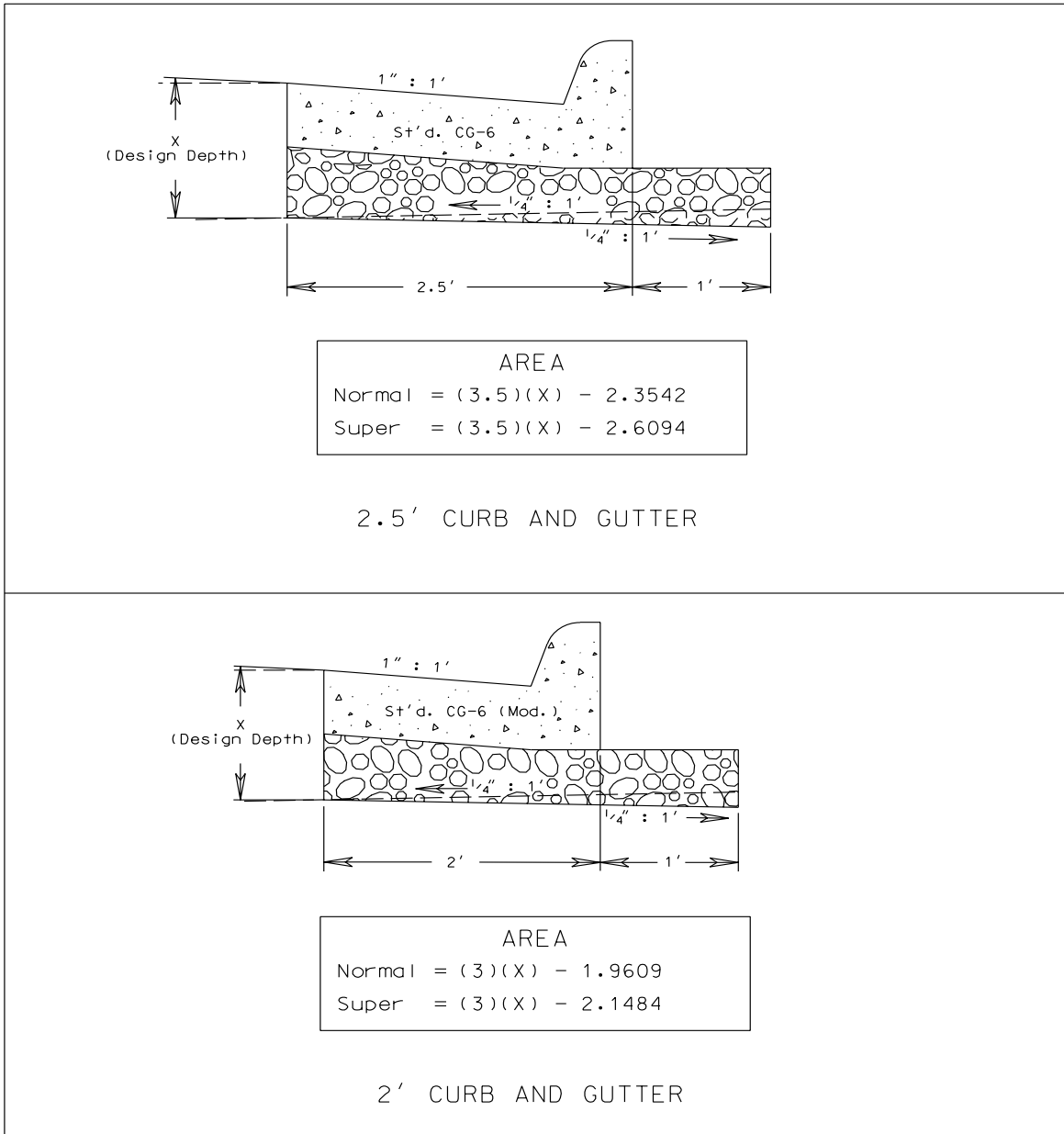
| (S)<br>Span of<br>Culvert<br>(inches) | Area (A)         |
|---------------------------------------|------------------|
|                                       | Sq. Ft.          |
|                                       | 3" x 1"<br>Corr. |
| 46                                    | 28.31            |
| 53                                    | 37.63            |
| 60                                    | 48.03            |
| 66                                    | 59.27            |

| (S)<br>Span of<br>Culvert<br>(inches) | Area (A)               |
|---------------------------------------|------------------------|
|                                       | Sq. Ft                 |
|                                       | 2 2/3" X 1/2"<br>Corr. |
| 49                                    | 28.92                  |
| 57                                    | 38.58                  |
| 64                                    | 49.07                  |
| 71                                    | 60.70                  |

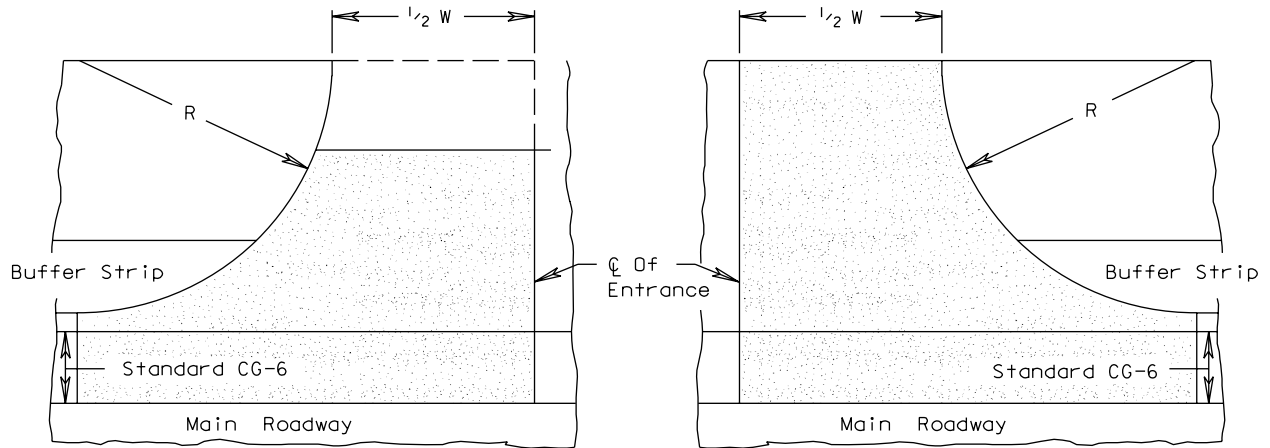
Area is given for one end section.  
Double area shown if two end sections are used

|                       |   |
|-----------------------|---|
| TO DETERMINE<br>RATIO | $\frac{A}{S \text{ (in feet)} \times \text{Length of Culvert}}$ |
|-----------------------|---|

**TABLE D-38 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION  
STANDARD ES-3**



**FIGURE D-2 SUBBASE END AREAS AT CURB AND GUTTER LOCATION**



**HALF PLAN  
AREA WITHOUT SIDEWALK**

**HALF PLAN  
AREA WITH SIDEWALK**

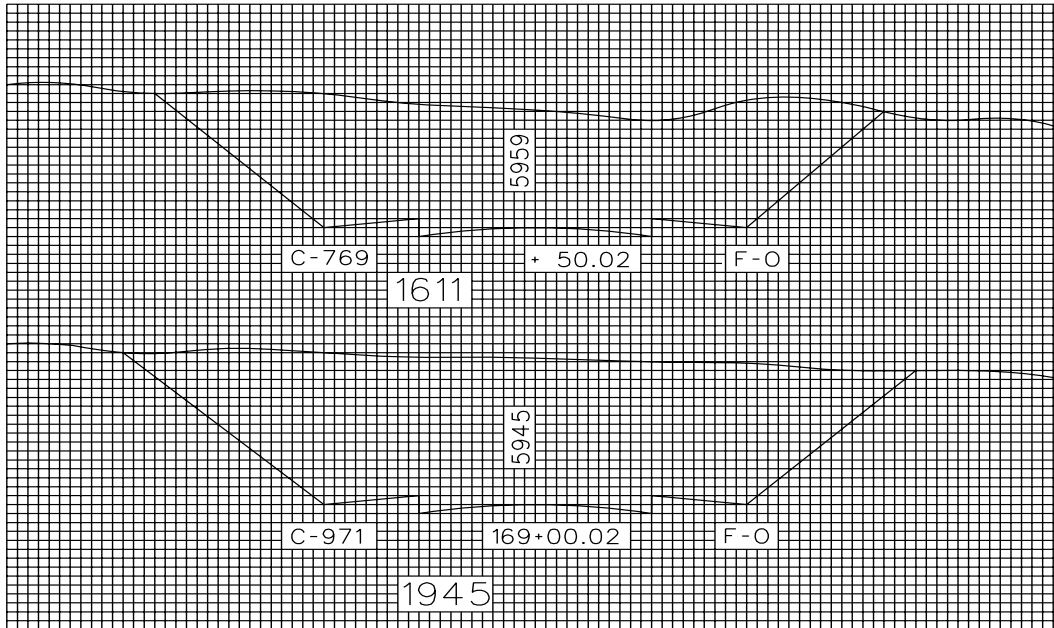
W= Width of Entrance



Area for computing ratio

| Width Of Entrance (Feet) | R = 6'           |                  | R = 7'           |                  | R = 8.5'         |                  |
|--------------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|                          | 2' Buffer Strip  |                  | 2' Buffer Strip  |                  | 2' Buffer Strip  |                  |
|                          | Without Sidewalk | With 4' Sidewalk | Without Sidewalk | With 5' Sidewalk | Without Sidewalk | With 5' Sidewalk |
|                          | Sq. Yds.         | Sq. Yds.         | Sq. Yds.         | Sq. Yds.         | Sq. Yds.         | Sq. Yds.         |
| 12                       | 14.36            | 16.39            | 15.47            | 18.90            | 17.21            | 22.84            |
| 16                       | 17.47            | 20.16            | 18.59            | 23.12            | 20.32            | 27.73            |
| 20                       | 20.58            | 23.94            | 21.70            | 27.34            | 23.43            | 32.62            |
| 24                       | 23.70            | 27.72            | 24.81            | 31.56            | 26.55            | 37.51            |
| 25                       | 24.47            | 28.66            | 25.59            | 32.62            | 27.32            | 38.73            |
| 26                       | 25.25            | 29.61            | 26.36            | 33.67            | 28.10            | 39.95            |
| 30                       | 28.36            | 33.39            | 29.47            | 37.89            | 31.21            | 44.84            |
| 36                       | 33.03            | 39.05            | 34.14            | 44.23            | 35.88            | 52.17            |
| 40                       | 36.14            | 42.83            | 37.25            | 48.45            | 38.99            | 57.06            |
| 42                       | 37.70            | 44.72            | 38.81            | 50.56            | 40.55            | 59.50            |
| 44                       | 39.25            | 46.61            | 40.36            | 52.67            | 42.10            | 61.95            |
| 48                       | 42.36            | 50.39            | 43.47            | 56.89            | 45.21            | 66.84            |
| 50                       | 43.92            | 52.28            | 45.03            | 59.01            | 46.77            | 69.29            |
| Each Additional Foot     | 0.778            | 0.944            | 0.778            | 1.056            | 0.778            | 1.222            |

**TABLE D-39 AREAS FOR ENTRANCE GUTTER STANDARD CG-9D**



The cut area of station 163+00.02 is 971 square feet, and the area of station 169+50.02 is 769 square feet. To find the average area of the two, we would add the two and divide by two.

$$\text{Thus, } \frac{971 + 769}{2} = \frac{1740}{2} = 870 \text{ Sq. Ft. (average)}$$

Now we must find the volume of the area between the two stations. The cross section has an average of 870 square feet and there is 50 feet between stations. Therefore, 870 multiplied by 50 equals 43,500 cubic feet to be removed from between these stations.

In order to arrive at 1611 cubic yards (this is the unit used as a basis of payment in earthwork) we divide the 43,500 cubic feet by 27, since there are twenty-seven cubic feet in one cubic yard.

The formula used to determine the volume of earthwork is called the AVERAGE END AREA METHOD and is noted below. Examine it closely.

$$\text{Volume} = \frac{L (A' + A'')}{2 \times 27}$$

L = distance between stations  
 A' = area of one station  
 A'' = area of second station  
 2 gets the average of A' & A''  
 27 converts cubic feet to cubic yards

EXAMPLE

$$\text{Volume} = \frac{50 (971 + 769)}{2 \times 27} = 1611$$

**FIGURE D-4 EARTHWORK QUANTITY COMPUTATIONS**