

Irrigated Acreage Determination Procedures for Wastewater Application Equipment

HARD HOSE TRAVELER

IRRIGATION SYSTEM



*North Carolina Cooperative
Extension Service*

North Carolina State University

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Irrigation continues to be the most practical and cost effective method of applying wastewater to fields so that the nutrients contained in the wastewater can be used by growing crops. However, irrigation systems have inherent application limitations that make field calibration, irrigation scheduling, and determination of irrigated acreage critical for proper use of the nutrients contained in the applied wastewater.

Irrigation systems are normally designed to satisfy equipment specifications provided in manufacturers' charts. Information presented in manufacturers' charts are based on average operating conditions for relatively new equipment. Discharge rates and precipitation rates change over time as equipment ages and components wear. Poor designs and/or improper operation can also cause poor performance. As a result, equipment should be field calibrated regularly to ensure that application rates and uniformity are consistent with values used during the system design and given in manufacturers' specifications. Field calibration is a simple procedure that involves collecting and measuring the material being applied at several locations in the application area. Step-by-step guidelines for field calibration of hard hose traveler irrigation systems are given in Extension publication AG-553-2, *Field Calibration Procedures for Animal Wastewater Application Equipment: Hard Hose and Cable Tow Traveler Irrigation System*.

Irrigation must be scheduled when fields are dry enough to retain all of the applied liquid within the root zone. If soils are too wet during irrigation, some of the applied wastewater may run off the field or leach below the root zone and become unavailable to the crop. These unused nutrients could contaminate surface or ground water supplies. Determining **when** and **how much** wastewater to apply for the prevailing conditions is referred to as **irrigation scheduling**. Irrigation scheduling techniques and procedures are outlined in Extension publication AG-452-4 *Irrigation Scheduling to Improve Water- and Energy-Use Efficiencies*.

Sprinkler irrigation systems do not apply water uniformly throughout their entire wetted radius. Application depths tend to be higher near the sprinkler and decrease gradually within the first 60 to 70 percent of the wetted radius. Beyond this point, the application depth declines quickly, dropping to zero at the outer edge. Irrigation design guidelines take equipment limitations into account in establishing recommended overlap ranges to optimize uniformity of coverage. Determining the uniformly irrigated area for traveler systems can be difficult for travel lanes along the perimeter of the field, for non-uniform travel lane spacings, or for excessive travel lane spacings with improper overlap. This publication contains step-by-step guidelines for determining irrigated acreage of hard hose traveler irrigation systems.

Background

Travel lane spacing and design guidelines have been developed primarily for freshwater irrigation with the primary goal of ensuring that those areas of the field receiving the least amount of water receive enough to sustain the crop and achieve yield goals. To achieve minimum desired application depths within the “lighter application zones,” travel lane spacings of 70 to 75 percent of the wetted sprinkler diameter have been determined to be “optimum” to compensate for the declining application along the perimeter. Closer lane spacings are sometimes economically justified for higher value crops; however, closer spacings may also result in some overlap zones receiving more water than necessary, and certainly more than the average. A good irrigation design considers these factors and uses a travel lane spacing that achieves a balance between the relative proportion of “under” and “over” irrigated area in order to achieve the most uniform application possible.

The application uniformity can be quantified using one of several uniformity indices. The uniformity index recommended for wastewater application is the Christiansen Uniformity Coefficient, U_c . Step-by-step computational procedures are outlined in Extension publication AG-553-2, referenced in the previous section. An application uniformity index of 60 is the minimum acceptable for wastewater application using hard hose traveler systems. Irrigation systems should be field calibrated regularly to ensure that application uniformity is within the acceptable range. Field calibration can also be used to determine the area within a field receiving a uniformly acceptable application.

Irrigated Acreage

In an effort to answer technical specialists’ questions and to provide uniform interpretations of the state’s animal waste management rules, the North Carolina General Assembly formed an interagency committee in

1996. The SB 1217 Interagency Committee is composed of two representatives of each of the five agencies with responsibilities for the development and/or enforcement of animal waste management rules. The committee recently adopted guidelines and procedures for determining the acreage that can be counted toward the “irrigated area” in satisfying the Certified Animal Waste Management Plan (CAWMP). The committee considered many factors including recommendations from irrigation engineers, certified irrigation designers, and industry representatives before arriving at these guidelines. The irrigated acreage determined by these procedures is intended to “reasonably and practically” account for physical limitations of the application equipment. The “irrigated acreage” computed by the procedures presented below must equal or exceed the acreage requirement specified in the CAWMP for proper nutrient use.

The irrigated area determination includes two broad categories: **existing irrigation systems**—those systems installed before the guidelines were finalized—and **new systems or expanded systems** installed after the SB 1217 committee released the third revision of the Sixth Guidance Document. Future updates and revisions may occur, so you should refer to the most recent Guidance Document for the latest interpretation and effective dates.

For the purpose of computing the irrigated acreage available to satisfy the CAWMP, the SB 1217 Interagency Committee adopted the term “**CAWMP wettable acre**” to be applied to **existing** systems. This term applies to existing systems that satisfy minimum specifications as outlined below. The irrigated acreage for **new** or **expanded irrigation** systems should continue to be based on standard irrigation design guidelines, which are based on the **effective design area**. The term expanded irrigation system applies to new irrigation components that wet an area of a field that was not wetted before adoption of the new guidelines. These terms are defined below.

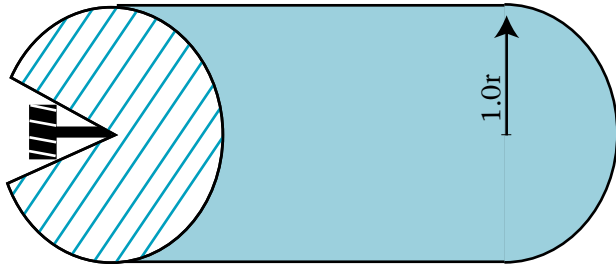


Figure 1. Area “wetted” during a single pull of a hard hose traveler.

Existing irrigation systems—For hard hose traveler systems designed and installed in accordance with minimum overlap guidelines (lane spacing between 60 and 90 percent of verified wetted diameter) and laid out with **multiple** overlapping lanes, the CAWMP wettable acre allowance is the entire “net wetted area” in the field. **The net wetted area is the part of the field that gets “wetted” during two or more parallel pulls of the gun when operated during normal conditions**, i.e., wind speed

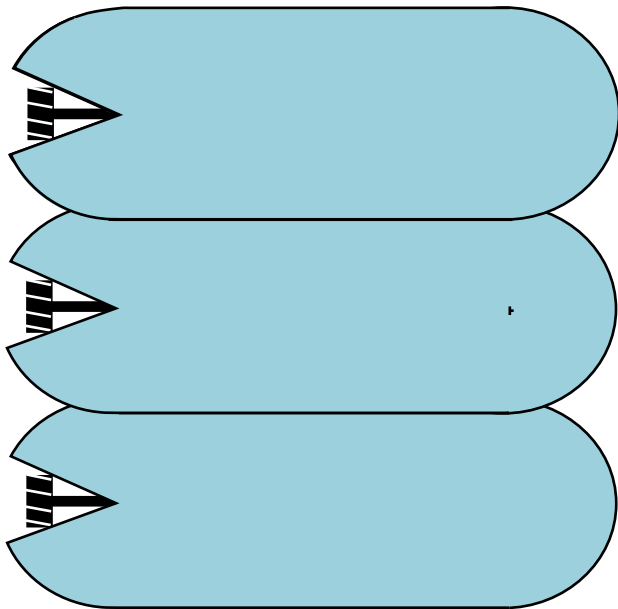


Figure 2. Shaded area shows net wetted area for a field irrigated with a hard hose traveler with multiple lanes. (The net wetted area for the three parallel pulls is less than three times the area of a single pull, Figure 1, due to overlap.)

under 5 mph.

The “wetted area” for a single pull without overlap is the area inscribed within the wetted diameter and length of pull as shown in Figure 1. For multiple pulls such as shown in Figure 2, the wetted area is also the entire shaded area; but, in this publication, this area is referred to as “net wetted area.” Due to the overlap, some of the same areas are wetted during adjacent pulls. These overlap areas cannot be counted twice, hence the term “net” is used.

For a hard hose traveler system, there are two travel lane designations within the field that affect determination of irrigated acreage.

- Interior travel lane
- Exterior travel lane

An **interior travel lane** is any lane that receives overlap on both sides of the pull as shown in Figure 3. The center lane is an interior lane. Travel lanes along the perimeter of the field receive overlap on just one side and are referred to as **exterior travel lanes**.

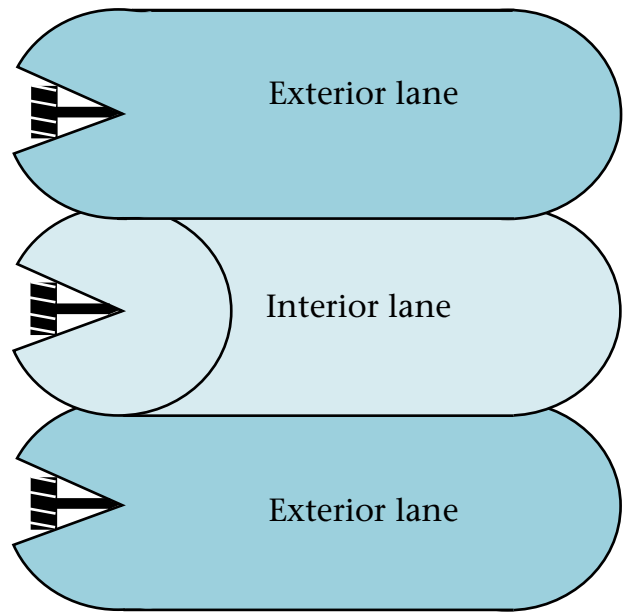


Figure 3. CAWMP wettable acre allowance for existing systems based on net wetted area for exterior (darker shaded) and interior travel lanes.

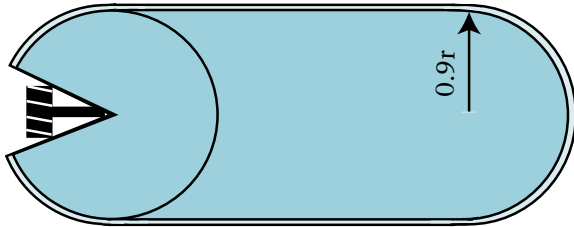


Figure 4. Shaded area shows allowable “irrigated area” for existing single pull hard hose traveler.

Note that the net wetted area allowance for an exterior lane is larger than the net wetted area allowance for an interior lane. This is due to overlap.

In single travel lanes with no overlap, the outer wetted edge cannot be counted under CAWMP wettable acre rules. In this case, the net wetted area is computed based on 90 percent of the verified wetted diameter as shown in Figure 4. For any system in which the lane spacing exceeds 90 percent of the verified wetted diameter, each lane should be treated as a “single lane” case.

The system layout, including determination of lane spacing and the number of interior and exterior lanes, must be determined in order to compute the CAWMP irrigated acreage of an existing system. The CAWMP wettable acre rules distinguish between existing systems with two or more overlapping travel lanes

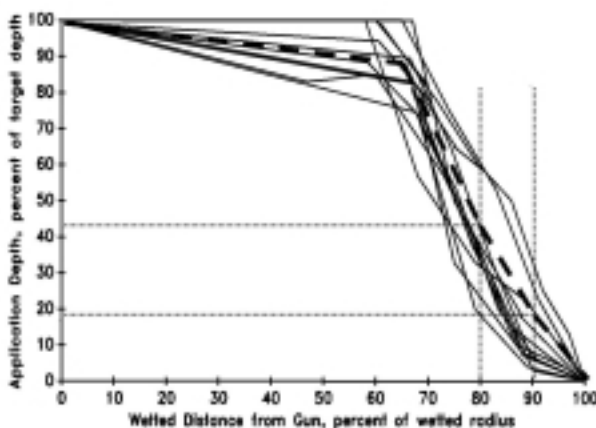


Figure 5. Normalized application depth versus distance from a gun or sprinkler.

and existing systems with only one travel lane without overlap. For multiple lanes, the CAWMP wettable acre allowance is “all” of the area wetted, whereas only 90 percent of the area wetted can be counted for single pulls.

New or Expanded Irrigation Systems—New or expanded irrigation systems must follow recommended design standards, which base the allowable irrigated area on **the effectively irrigated area, referred to in this publication as the “design area.”**

The effective irrigated area is the wetted area that receives at least 50 percent of the target application amount. From field calibration measurements, this has been determined to be the area that falls within 78 percent of the wetted radius as shown in Figure 5. Note that application depths remain within 90 percent of the target amount out to 60 percent of the wetted radius. Between 60 and 70 percent of the wetted radius, application amounts still remain within 80 percent of the target application amount. But beyond 70 percent of the wetted radius, application amounts drop off quickly, declining to 50 percent by 78 percent of the wetted radius. At 90 percent of the wetted radius, the application depth drops below 20 percent. Traditional design spacing guidelines established by the North Carolina Cooperative Extension Service for traveling gun systems have been for 60 to 75 percent of manufacturers’ published wetted diameter. These recommendations are strongly collaborated by the data shown in Figure 5. A multi-travel lane system (such as shown in Figure 2 or 3), operated under light wind with exactly a 78 percent lane spacing, would result in a nearly perfect application uniformity. Even if the lane spacing were stretched out to 85 percent of the wetted diameter, the minimum application amount would be 50 percent of the target amount along the overlapped zone, which would still result in acceptable uniformity. It should be noted that the results shown in Figure 5 are based on field-verified wetted

diameters. Recent measurements on more than 50 systems determined that field-measured wetted diameters averaged 10 percent less than values published in manufacturers' literature. A spacing based on 85 percent of field-verified wetted diameter is roughly the same as a spacing based on 77 percent of manufacturers' values. Thus, a design spacing recommendation of 60 to 75 percent of manufacturers' values (N.C. Cooperative Extension Service guideline) is a conservative recommendation to ensure that enough wastewater is applied in the lighter application zones. The Extension recommendations should continue to be applied to new or expanded systems. Spacings greater than 85 percent of the verified wetted diameter or 75 percent of the wetted diameter published in manufacturers' literature are considered excessive and result in unacceptable uniformity.

For existing irrigation systems involving a single pull or excessive lane spacing, the CAWMP wettable acre should be based on no more than 90 percent of the verified wetted gun diameter as shown in Figure 4. When using new systems with single pulls or excessive lane spacing, base the CAWMP wettable acre on no more than 75 percent of the manufacturer's published wetted gun diameter as shown in Figure 6.

Field Measurements

To accurately calculate the irrigated area, determine the wetted diameter or radius of the gun. There are two methods for determining the wetted diameter, and both require operating the system:

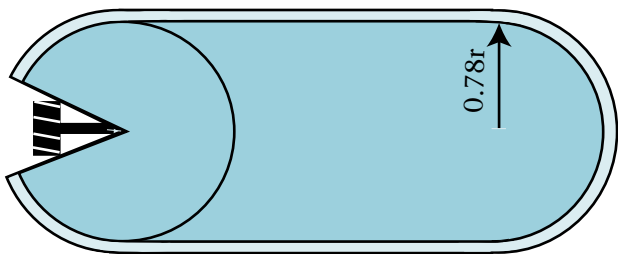


Figure 6. Shaded area shows allowable irrigated area based on “effective design area” for new or expanded systems.

- Directly measure the wetted diameter (footprint), or
- Measure gun pressure, then read the wetted diameter from manufacturers' charts for the observed pressure.

The recommended procedure is to determine the wetted diameter (also referred to as wetted footprint) rather than rely on pressure and manufacturers' tables. Values given in manufacturers' charts tend to be about 10 percent higher than values measured in field calibrations. Regardless of the method used, collect field data and record it on the Field Data Worksheet provided at the end of this publication.

Footprint measurement—Footprint measurement involves observing, marking, and measuring the farthest distance from the gun that gets wetted. Field data should be collected on the lane farthest from the pump. Measuring two or more different lanes improves the reliability of the field procedures. Measurements should be made during very light wind (less than 5 mph). The wetted distance from the gun should be determined on both sides of the lane along the perimeter as indicated in Figure 7. The system should be operated long enough for all air to be purged from the system before starting to make measurements.

With the system operating at normal pressure:

1. Standing just outside the wetted perimeter, observe and flag the farthest point getting wetted for each of three consecutive passes of the gun.
2. Select one flag to mark the average distance of the three observations. Remove the other two flags.
3. Move to the other side of the lane (180 degrees around the wetted perimeter) and repeat steps 1 and 2. The wetted perimeter should be flagged on two sides of the gun as shown in Figure 7.

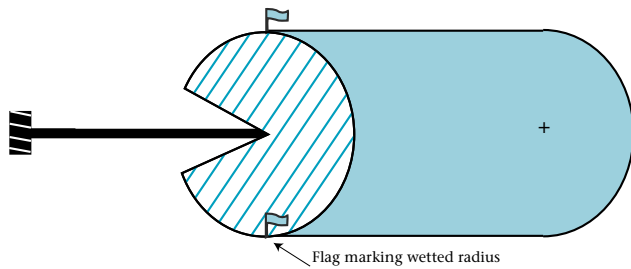


Figure 7. Field measurements to determine “wetted diameter” of a hard hose traveler.

4. Measure and record the distances from the gun (travel lane) to each flag.
5. Compare the two measurements and if the values are within 5 percent, compute the average of the two; this will be the wetted radius. If the difference between the measurements is more than 5 percent, repeat steps 1 through 4 at another location along the lane or along a different lane.
6. If the difference between the second set of measurements is also greater than 5 percent, the wind speed may be too high, resulting in excessive drift; or, the gun may be functioning improperly. Once you have eliminated or corrected the cause of the variability, repeat, beginning with step 1. If you cannot correct the problem, contact an irrigation technical specialist.

Pressure measurement—The wetted diameter can also be estimated from pressure measurements at the gun. **Pump pressure is NOT an acceptable substitute.**

Collect field data when the system is operated on the lane farthest from the pump. You should operate the system long enough for all air to be purged from the system before measuring the pressure.



Figure 8. Pressure gauge installed on a traveling gun.

Gun type sprinklers have a port for installing a pressure gauge, shown in Figure 8. A glycerin-filled gauge is recommended. Permanently installed gauges are likely to foul, so it is also recommended that you install a shut-off valve between the gauge and gun. The valve can be opened long enough to read the pressure, then closed to extend the life of the gauge.

It is also necessary to determine the exact size of the nozzle opening. Most manufacturers stamp the nozzle size on the end of the nozzle. If the nozzle opening cannot be read, a precise measurement using calipers is required.

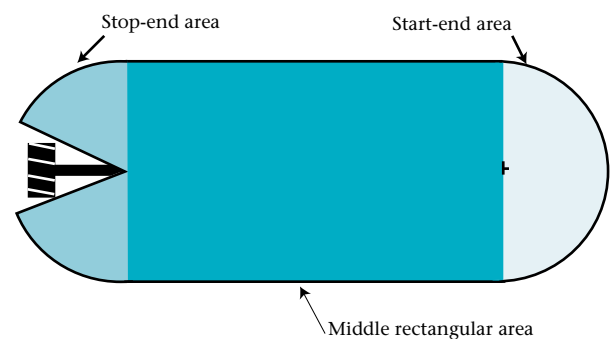


Figure 9. Area components of traveler pull required to compute total irrigated area for a lane.

Once you measure the operating pressure and nozzle opening, estimate the wetted diameter from the manufacturer's literature. When using tables in this publication to determine irrigated acreage, **reduce the value taken from manufacturers' charts by 10 percent.**

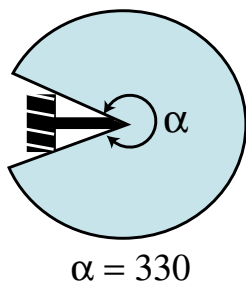


Figure 10. Recommended arc angle of gun for use with hard hose traveler.

The gun pressure can sometimes be estimated based on direct pressure measurements at the reel if pressure losses in the flexible hose and drive mechanism are properly accounted for. This procedure should be used only when footprint measurement or pressure measurement at the gun cannot be completed.

Determining Irrigated Acreage

Once you collect the necessary field data and determine the wetted radius or diameter, compute the **CAWMP wettable acres**. Computations are not difficult; but they can become cumbersome for non-uniform lane spacings, lane spacings with improper overlap, and pulls along the perimeter of the field. To simplify the determination of irrigated acreage, computations have been tabulated for the end areas of the pull for typical lane spacings and patterns. Use of these tables requires precise determination of wetted diameter, system layout, and the number of interior and exterior travel lanes as defined earlier. Step-by-step computational procedures are outlined in the Computational Worksheet provided at the end of this publication. A flowchart for using the tables is shown in Figure 14.

Existing systems with multiple lanes:

Determining the irrigated area for each pull

involves doing calculations for three area components of the pull—"start-end" area, "middle" area, and "stop-end" area. These areas are shown in Figure 9.

Start-end area—Start-end areas have been computed for lane spacings between 60 to 90 percent of wetted diameter and are shown in column (B) in **Tables EE60 to EE90** for Existing Exterior (EE) lanes and **Tables EI60 to EI90** for Existing Interior (EI) lanes.

Middle area—The middle area must be computed based on the net wetted width and the length of pull. There are endless combinations of "length of pull," so it is not practical to tabulate these values. Instead, you should compute this area by multiplying the length and width of the rectangular area shown in Figure 9.

Stop-end area—The stop-end area is influenced by the wetted diameter of the gun and the angle of gun rotation referred to as "gun arc angle," shown in Figure 10. Gun arc angles commonly range from 180 to 330 degrees. Typical arc angles are shown in Figure 11. Stop-end areas based on several common arc angles are tabulated in columns C through G of **Tables EE60 to EE90** for existing exterior lanes and **Tables EI60 to EI90** for existing interior lanes.

Existing system with single lane or lane spacing greater than 90 percent.

Irrigated acreage determination for fields with a single pull or where the lane spacing exceeds 90 percent of the wetted diameter involves determination of the three area components just as in the previous section. However, only 90 percent of the wetted area is used in computing the irrigated area. Use **Table E90+** for existing systems with single pulls or when lane spacings exceed 90 percent of wetted diameter.

New or expanded systems: Determination of irrigated area for new or expanded systems involves determination of the three area components—start-end, middle, and stop-end areas. But irrigated acreage

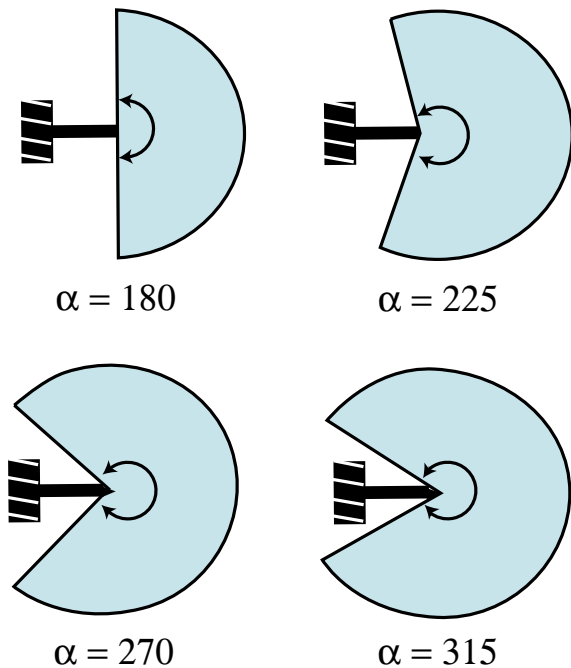


Figure 11. Typical gun arc angles used for traveling gun systems.

for new or expanded systems is based on the effective design area, which is computed based on 78 percent of the wetted diameter. These values are given in **Tables NE60 to NE75** for New Exterior (NE) lanes and **Tables NI60 to NI75** for New Interior (NI) lanes. Values for new single lane systems are shown in **Table N75+**.

You should follow these general guidelines in using the tabulated values presented in this publication. Make decisions on a field-by-field basis as referenced in the CAWMP.

1. Determine the number of **interior** and **exterior** lanes for each field.
2. Determine whether the system in each field satisfies the **existing** or **new** designation.

3. Obtain the lane spacing from the Field Data Worksheet (i.e., field-measured lane spacing).
4. Determine whether the system satisfies the **multiple lane** or **single lane** definition. If the lane spacing exceeds 90 percent of the verified wetted diameter, treat the system as an existing system with single pulls and read the irrigated acreage from Table E90+.
5. Read or compute the irrigated area per lane for the given wetted diameter from the appropriate column based on gun position, lane spacing, and lane position.

Start-end area

Read the irrigated area for the start-end of the pull from column B of the appropriate table based on lane spacing and position (exterior or interior).

Rectangular area (middle component)

Compute the area of the rectangular component using the formula:

Exterior lane

Middle area = length of pull x (wetted diameter / 2 + lane spacing / 2) / 43,560

Interior lane

Middle area = (length of pull x lane spacing) / 43,560

Stop-end area

Read the irrigated area for the stop-end of the pull from the appropriate table based on lane spacing and position (exterior or interior) and gun arc angle, columns C through G.

If the lane spacing falls between the tabulated values, interpolate or round **down** and use

the table for the next lowest value shown. For example, if the computed spacing is between 70 and 74 percent, use the 70 percent table.

6. Add the area components for each pull, then add all of the pulls. This is the total irrigated acreage for the field.

Determining Irrigated Acreage

EXAMPLES

Case I: Multiple lanes

Figure 12 shows a typical lane spacing and pattern for a hard hose traveler system. This existing system has five pulls laid out in the field. The travel distance of the gun is 820 feet and the gun angle is 330 degrees.

1. Determine the number of interior and exterior lanes for each field. In Figure 12, lanes 1 and 5 are exterior lanes; lanes 2, 3, and 4 are interior lanes.

Number of **exterior** lanes = 2

Number of **interior** lanes = 3

2. Determine whether the system in each field satisfies the **existing** or **new** designation. System satisfies existing designation.

3. Using the Field Data Worksheet, determine the lane spacing.

The lane spacing (item 6) is **220 feet**. The wetted diameter (item 7) is **290 feet**.

Lane spacing as a percentage of wetted diameter is: $220 \text{ feet} / 290 \text{ feet} = 75.9 \text{ percent}$

4. Determine whether the system satisfies the **multiple lateral** or **single lateral** definition. System satisfies the **multiple lateral** system definition with lateral spacing equal to 75.9 percent of wetted diameter.

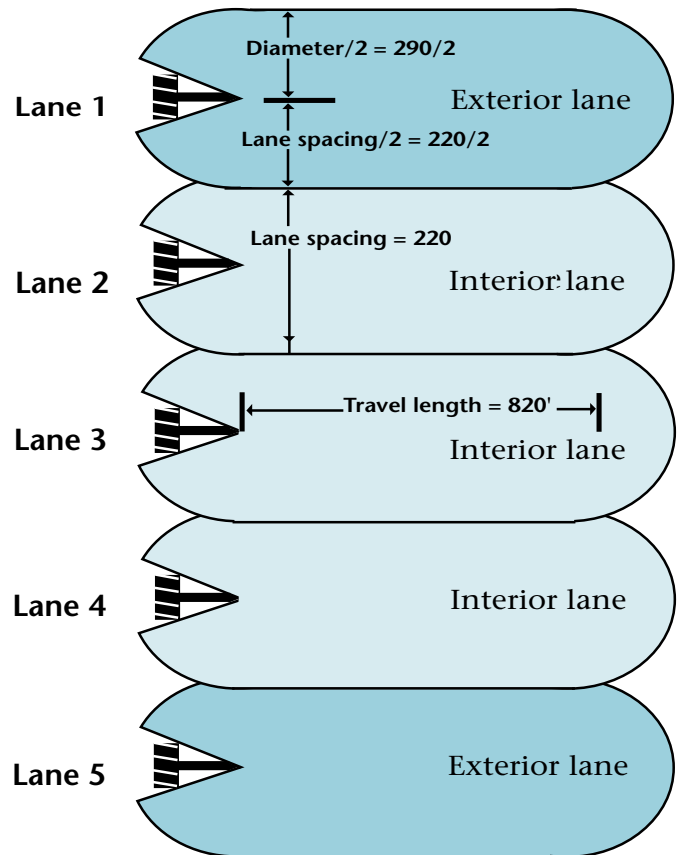


Figure 12. Hard hose traveler irrigated area determination.

5. Read the irrigated area per lane for the given wetted diameter from the appropriate column based on gun position, lane spacing, and lane position. For a wetted diameter of 290 feet and lane spacing of 75 percent:

Exterior lane, Table EE75

Start-end area = **0.70 acres**

Middle area = $820 \text{ feet} \times (290 \text{ feet} / 2 + 220 \text{ feet} / 2) / 43,560 = \mathbf{4.80 \text{ acres}}$

Stop-end area (315 arc angle) = **0.51 acres**

Total for exterior = $0.70 + 4.80 + 0.51 =$

6.01 acres

Interior lane, Table EI75
Start-end area = **0.65 acres**

Middle area = (820 feet x 220 feet)
/43,560 = **4.14 acres**

Stop-end area (315 arc angle) = **0.46 acres**

Total for interior = 0.65 + 4.14 + 0.46 =
5.25 acres

6. Multiply the areas from step 5 by the number of lanes in each category. Add these. The sum is the total irrigated acreage for the field.

2 exterior lanes X 6.01 acres/lane =
12.02 acres

3 interior lanes X 5.25 acres/lane =
15.75 acres

Total irrigated area of field
12.02 ac + 15.75 ac = **27.77 acres**

Case II: Single lane (also use this procedure for lane spacing greater than 90 percent of wetted diameter).

Figure 13 shows a typical field situation that would result in a single lane. Data and irrigated area must be reported on a field-by-field basis. These fields are surrounded by drainage ditches spaced 330 feet apart. This existing system has one lane per field and uses a model 150 gun. The travel distance of the gun is 900 feet, and the gun angle is 270 degrees.

1. Determine the number of **interior** and **exterior** lanes for each field. In Figure 13, there is only one pull per field.

Number of lanes per field = 1

2. Determine whether the system in each field

satisfies the **existing** or **new** designation.

System satisfies **existing** designation.

3. Using the Field Data Worksheet, determine the lane spacing.

Not applicable since there is only one lane per field.

4. Determine whether the system satisfies the **multiple lane** or **single lane** definition.

System satisfies **single lane**.

5. Read the irrigated area per lane for the given wetted diameter from the appropriate column based on gun position, lane spacing, and lane position. For a wetted diameter of 290 feet and single lane system:

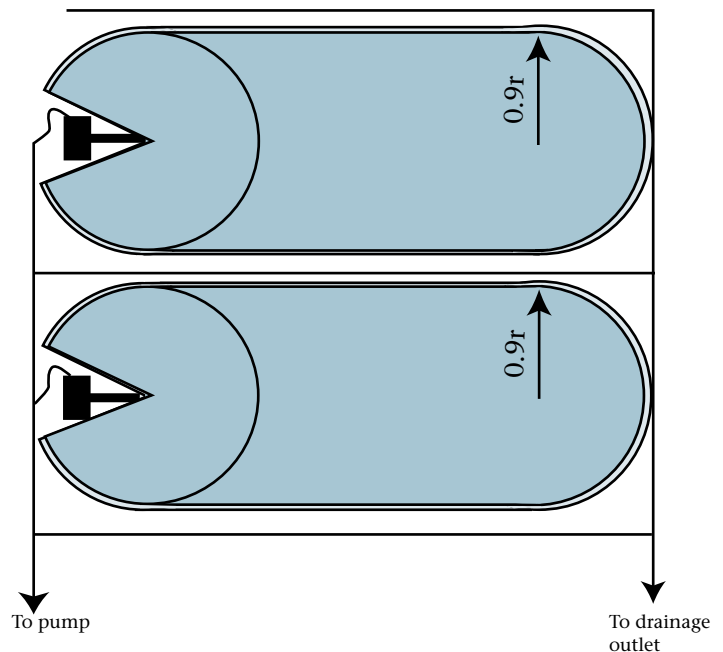


Figure 13. Typical field layout where only one pull occurs in each field.

From Table E90+

Start-end area = **0.61 acres**

Middle area = 900 feet x (0.9 X 290 feet)/43,560
= **5.39 acres**

Stop-end area (270 arc angle) = **0.31 acres**

Total irrigated area for field =
0.61 + 5.39 + 0.31 = **6.31 acres**

- Multiply the areas from step 5 by the number of lanes in each category. Add these. The sum is the total irrigated acreage for the field. Since there is only one lane per field and irrigated acres must be reported on a field-by-field basis, the irrigated area for the field is the same as computed in step 5.

Summary

Animal waste management operations that rely on spray irrigation systems may be required to have a wettable acre determination completed to ensure nutrients contained in the wastewater are applied to adequate land at agronomic rates. All CAWMP will be reviewed by state Division of Water Quality or Division of Soil and Water field inspectors to determine whether a wettable acre determination is indeed required. If so, the Field Data Worksheet and Computational Worksheet that follow will have to be completed for traveling gun systems and added to the CAWMP. A wettable acre (WA) designated technical specialist must complete and sign the Computational Worksheet to certify that the irrigation system can be operated so that the wastewater nutrients are applied to appropriate areas. Step-by-step procedures for completing the CAWMP wettable acres determination have been developed along with tables from which irrigated acreage can be determined for various irrigation system designs.

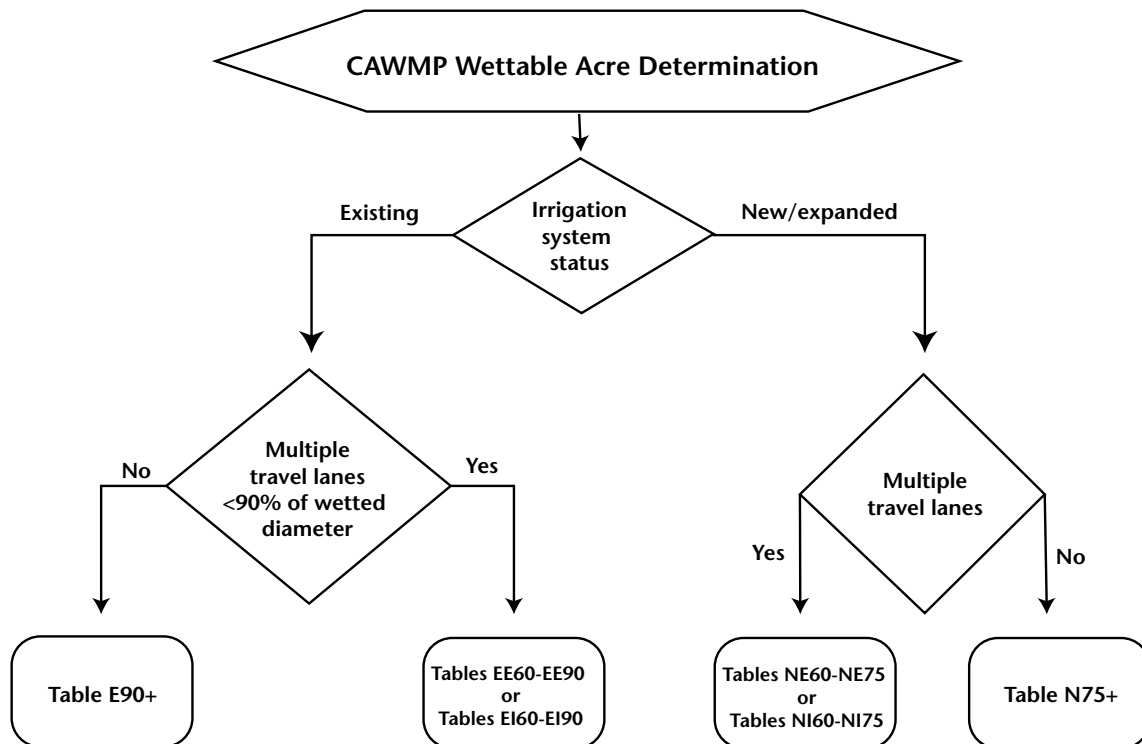


Figure 14. Flowchart showing decision-making process for identifying which tables to use to determine CAWMP wettable acres for traveling gun irrigation systems.

CAWMP Wettable Acre Terms

CAWMP wetable acre—the irrigated acreage that the SB 1217 Interagency Committee allows to be counted toward the land application area requirement of the Certified Animal Waste Management Plan (CAWMP) for existing irrigation systems.

Effective design area—the portion of the wetted area that receives at least 50 percent of the target application amount. Land application acreage for new or expanded irrigation systems must be based on effective design area.

Excessively spaced travel lane—parallel travel lane spacing that exceeds allowable spacing recommendations. For existing traveling gun systems, this refers to spacings in excess of 90 percent of the verified wetted diameter. For new or expanded traveling gun systems, it refers to spacings in excess of 75 percent of the manufacturer's published wetted diameter.

Existing irrigation system—an irrigation system that was installed before release of the third revision of the Sixth Guidance Document.

Multiple lane irrigation system—an existing irrigation system with two or more parallel lanes equally spaced between 60 and 90 percent of the verified wetted diameter.

Net wetted area—the part of the field that gets wetted when two or more sprinklers are operated with overlapping radii.

New or expanded irrigation system—any component of an irrigation system that wets a portion of a field that was not wetted before release of the third revision of the Sixth Guidance Document.

Single lane irrigation system—an existing irrigation system with only one travel lane per field or one with excessively spaced lanes. For existing systems, lane spacings greater than 90 percent of the verified wetted diameter are considered excessive. For new or expanded systems, lane spacings in excess of 75 percent of the manufacturer's published wetted diameter are considered excessive.

Verified wetted diameter—field-measured distance from one side of the wetted width of a pull to the opposite side of the wetted width of the pull.

Wetted area—the area that becomes wetted as a traveling gun is pulled toward a reel.

Wetted diameter—the distance from one side of a wetted perimeter through the point of gun rotation to the opposite side of the wetted perimeter. Wetted diameter is twice the wetted radius.

Wetted radius—the distance from the gun to a point along the edge of the wetted perimeter. Wetted radius is the distance the gun throws water.

Hard Hose Traveling Gun System FIELD DATA WORKSHEET*

1. Make and model number _____
2. Hose length _____ [feet] and hose inside diameter (ID) _____ [inch]
3. Gun make and model number _____
4. Gun nozzle size _____ [inch], _____ ring orifice, _____ taper bore orifice
5. Gun arc angle _____ [degrees]
6. Travel lane spacing _____ [feet]. Indicate whether ____ uniform or ____ random.
Number of exterior hydrants _____. Number of interior hydrants _____.
7. Gun wetted diameter _____ [feet]. ____ measured or ____ based on gun chart.
8. Gun pressure _____ [psi] _____ observed at working gauge,
_____ determined from gun charts, ____ calculated (show calculations)
- **9. Operating pressure at hose reel _____ [psi]. ____ observed at working gauge or
_____ provided by owner.
- **10. Supply line size _____ [inch] (from pump to last hydrant)
- **11. Supply line length _____ feet (maximum pumping distance)
- **12. Supply line type _____ PVC or _____ aluminum
- **13. Pump make and model number _____
- **14. Pump capacity _____ [gpm]
- **15. Engine make and model number _____
or
- **16. Electric motor horsepower and rpm _____ [hp] _____ [rpm]

Note: It is strongly recommended that you field determine wetted diameter and operating pressure at the reel and gun.

- * Locate each hydrant on a copy of the map. Indicate the start and stop of the sprinkler cart for each travel lane and show the distance traveled. Show the location of the supply line. Irrigated acres are determined by the travel lane.
- ** Optional data, furnish where possible.

*** Information furnished by

Signature of owner or facility representative and/or _____
Signature of technical specialist

Printed name of owner or facility representative _____
Printed name of technical specialist

Date _____ Date _____

*** Only the person or people collecting the data should sign the Field Data Worksheet.

Hard Hose Traveling Gun System COMPUTATIONAL WORKSHEET

1. Farm number (identification) _____ Field number (identification) _____
2. Irrigation system designation ___ Existing irrigation system ___ New/expanded irrigation system
3. Number of travel lanes _____ # Interior lanes _____ # Exterior lanes _____ [feet] Length of pull(L1)
 _____ # Interior lanes _____ # Exterior lanes _____ [feet] Length of pull(L2)
 _____ # Interior lanes _____ # Exterior lanes _____ [feet] Length of pull(L3)
4. Wetted diameter _____ [feet] from Field Data Worksheet
5. Spacing _____ Hydrant spacing [feet] _____ [as a percentage of wetted diameter]
6. Hydrant layout ___ Multiple hydrants ___ Single hydrant ___ Excessively spaced hydrants
7. Read the irrigated area per travel pull for the given wetted diameter from the appropriate table and column based on pattern, spacing, and travel lane location.

Travel lane length (L₁) ___ Interior or ___ Exterior (lane/hydrant)
 _____ (a) Acres start end of pull from Table _____ Column _____
 _____ (b) Acres middle portion of pull (L1)
 {Pull length _____ [feet] X Wetted width _____ [feet]} / 43,560
 _____ (c) Acres stop end of pull from Table _____ Column _____

_____ **Total acres for travel lane length (L1) (Sum: a + b + c)**

Travel lane length (L₂) ___ Interior or ___ Exterior (lane/hydrant)
 _____ (a) Acres start end of pull from Table _____ Column _____
 _____ (b) Acres middle portion of pull (L2)
 {Pull length _____ [feet] X Wetted width _____ [feet]} / 43,560
 _____ (c) Acres stop end of pull from Table _____ Column _____

_____ **Total acres for travel lane length (L2) (Sum: a + b + c)**

Travel lane length (L₃) ___ Interior or ___ Exterior (lane/hydrant)
 _____ (a) Acres start end of pull from Table _____ Column _____
 _____ (b) Acres middle portion of pull (L3)
 {Pull length _____ [feet] X Wetted width _____ [feet]} / 43,560
 _____ (c) Acres stop end of pull from Table _____ Column _____

_____ **Total acres for travel lane length (L3) (Sum: a + b + c)**

8. Multiply the tabulated irrigated acreage value per travel pull by the number of pulls of each category in the field. Add all of these, and this is the total irrigated acreage for the field.

_____ (a) Acres per travel lane length (L1) X _____ # Lanes = _____ Acres
 _____ (b) Acres per travel lane length (L2) X _____ # Lanes = _____ Acres
 _____ (c) Acres per travel lane length (L3) X _____ # Lanes = _____ Acres

_____ **Total CAWMP wettable acres for field (Sum: 8a + 8b + 8c)**

Wettable Acre Computational Worksheet Completed by: _____ Date: _____

Signature of technical specialist

Table EE60. Area Allowances for **Existing** Hard Hose Traveler Systems
Exterior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **60 percent** of verified wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.17	0.00	0.03	0.07	0.12	0.14
160	0.20	0.00	0.04	0.08	0.14	0.16
170	0.22	0.00	0.04	0.09	0.16	0.18
180	0.25	0.00	0.05	0.11	0.18	0.20
190	0.28	0.00	0.06	0.12	0.20	0.22
200	0.31	0.00	0.06	0.13	0.22	0.25
210	0.34	0.00	0.07	0.14	0.24	0.27
220	0.37	0.00	0.08	0.16	0.27	0.30
230	0.41	0.00	0.08	0.17	0.29	0.33
240	0.45	0.00	0.09	0.19	0.32	0.36
250	0.48	0.00	0.10	0.21	0.34	0.39
260	0.52	0.00	0.11	0.22	0.37	0.42
270	0.56	0.00	0.11	0.24	0.40	0.45
280	0.61	0.00	0.12	0.26	0.43	0.49
290	0.65	0.00	0.13	0.28	0.46	0.52
300	0.70	0.00	0.14	0.30	0.49	0.56
310	0.74	0.00	0.15	0.32	0.53	0.60
320	0.79	0.00	0.16	0.34	0.56	0.64
330	0.84	0.00	0.17	0.36	0.60	0.68
340	0.89	0.00	0.18	0.38	0.63	0.72
350	0.95	0.00	0.19	0.40	0.67	0.76
360	1.00	0.00	0.20	0.43	0.71	0.81
370	1.06	0.00	0.21	0.45	0.75	0.85
380	1.12	0.00	0.22	0.47	0.79	0.90
390	1.18	0.00	0.24	0.50	0.83	0.95
400	1.24	0.00	0.25	0.53	0.88	1.00
410	1.30	0.00	0.26	0.55	0.92	1.05
420	1.36	0.00	0.27	0.58	0.97	1.10
430	1.43	0.00	0.29	0.61	1.01	1.15
440	1.50	0.00	0.30	0.64	1.06	1.21
450	1.57	0.00	0.31	0.67	1.11	1.26
460	1.64	0.00	0.33	0.70	1.16	1.32
470	1.71	0.00	0.34	0.73	1.21	1.38
480	1.78	0.00	0.36	0.76	1.26	1.44
490	1.86	0.00	0.37	0.79	1.32	1.50
500	1.93	0.00	0.39	0.82	1.37	1.56

Table EE65. Area Allowances for **Existing** Hard Hose Traveler Systems
Exterior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **65 percent** of verified wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.18	0.00	0.04	0.08	0.13	0.15
160	0.20	0.00	0.04	0.09	0.15	0.17
170	0.23	0.00	0.05	0.10	0.16	0.19
180	0.26	0.00	0.05	0.11	0.18	0.21
190	0.29	0.00	0.06	0.13	0.21	0.23
200	0.32	0.00	0.07	0.14	0.23	0.26
210	0.35	0.00	0.07	0.15	0.25	0.28
220	0.39	0.00	0.08	0.17	0.28	0.31
230	0.42	0.00	0.09	0.18	0.30	0.34
240	0.46	0.00	0.09	0.20	0.33	0.37
250	0.50	0.00	0.10	0.22	0.36	0.40
260	0.54	0.00	0.11	0.23	0.39	0.44
270	0.58	0.00	0.12	0.25	0.42	0.47
280	0.62	0.00	0.13	0.27	0.45	0.51
290	0.67	0.00	0.14	0.29	0.48	0.54
300	0.72	0.00	0.15	0.31	0.51	0.58
310	0.76	0.00	0.16	0.33	0.55	0.62
320	0.81	0.00	0.17	0.35	0.58	0.66
330	0.87	0.00	0.18	0.38	0.62	0.70
340	0.92	0.00	0.19	0.40	0.66	0.75
350	0.97	0.00	0.20	0.42	0.70	0.79
360	1.03	0.00	0.21	0.45	0.74	0.84
370	1.09	0.00	0.22	0.47	0.78	0.88
380	1.15	0.00	0.24	0.50	0.82	0.93
390	1.21	0.00	0.25	0.53	0.87	0.98
400	1.27	0.00	0.26	0.55	0.91	1.03
410	1.34	0.00	0.27	0.58	0.96	1.08
420	1.40	0.00	0.29	0.61	1.01	1.14
430	1.47	0.00	0.30	0.64	1.05	1.19
440	1.54	0.00	0.32	0.67	1.10	1.25
450	1.61	0.00	0.33	0.70	1.15	1.31
460	1.68	0.00	0.34	0.73	1.21	1.37
470	1.76	0.00	0.36	0.77	1.26	1.43
480	1.83	0.00	0.38	0.80	1.31	1.49
490	1.91	0.00	0.39	0.83	1.37	1.55
500	1.99	0.00	0.41	0.87	1.43	1.61

Table EE70. Area Allowances for **Existing** Hard Hose Traveler Systems
Exterior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **70 percent** of verified wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.18	0.00	0.04	0.08	0.13	0.15
160	0.21	0.00	0.04	0.09	0.15	0.17
170	0.24	0.00	0.05	0.11	0.17	0.19
180	0.26	0.00	0.06	0.12	0.19	0.22
190	0.29	0.00	0.06	0.13	0.21	0.24
200	0.33	0.00	0.07	0.15	0.24	0.27
210	0.36	0.00	0.08	0.16	0.26	0.29
220	0.40	0.00	0.08	0.18	0.29	0.32
230	0.43	0.00	0.09	0.19	0.31	0.35
240	0.47	0.00	0.10	0.21	0.34	0.38
250	0.51	0.00	0.11	0.23	0.37	0.42
260	0.55	0.00	0.12	0.25	0.40	0.45
270	0.60	0.00	0.12	0.27	0.43	0.49
280	0.64	0.00	0.13	0.29	0.46	0.52
290	0.69	0.00	0.14	0.31	0.50	0.56
300	0.74	0.00	0.15	0.33	0.53	0.60
310	0.78	0.00	0.16	0.35	0.57	0.64
320	0.84	0.00	0.18	0.37	0.61	0.68
330	0.89	0.00	0.19	0.40	0.64	0.73
340	0.94	0.00	0.20	0.42	0.68	0.77
350	1.00	0.00	0.21	0.45	0.72	0.82
360	1.06	0.00	0.22	0.47	0.77	0.86
370	1.12	0.00	0.23	0.50	0.81	0.91
380	1.18	0.00	0.25	0.53	0.85	0.96
390	1.24	0.00	0.26	0.56	0.90	1.01
400	1.31	0.00	0.27	0.59	0.95	1.07
410	1.37	0.00	0.29	0.62	0.99	1.12
420	1.44	0.00	0.30	0.65	1.04	1.18
430	1.51	0.00	0.32	0.68	1.09	1.23
440	1.58	0.00	0.33	0.71	1.14	1.29
450	1.65	0.00	0.35	0.74	1.20	1.35
460	1.73	0.00	0.36	0.77	1.25	1.41
470	1.80	0.00	0.38	0.81	1.31	1.47
480	1.88	0.00	0.39	0.84	1.36	1.54
490	1.96	0.00	0.41	0.88	1.42	1.60
500	2.04	0.00	0.43	0.91	1.48	1.67

Table EE75. Area Allowances for **Existing** Hard Hose Traveler Systems
Exterior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **75 percent** of verified wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.19	0.00	0.04	0.09	0.14	0.15
160	0.21	0.00	0.05	0.10	0.16	0.18
170	0.24	0.00	0.05	0.11	0.18	0.20
180	0.27	0.00	0.06	0.12	0.20	0.22
190	0.30	0.00	0.06	0.14	0.22	0.25
200	0.33	0.00	0.07	0.15	0.24	0.27
210	0.37	0.00	0.08	0.17	0.27	0.30
220	0.40	0.00	0.09	0.19	0.30	0.33
230	0.44	0.00	0.09	0.20	0.32	0.36
240	0.48	0.00	0.10	0.22	0.35	0.40
250	0.52	0.00	0.11	0.24	0.38	0.43
260	0.57	0.00	0.12	0.26	0.41	0.46
270	0.61	0.00	0.13	0.28	0.45	0.50
280	0.66	0.00	0.14	0.30	0.48	0.54
290	0.70	0.00	0.15	0.32	0.51	0.58
300	0.75	0.00	0.16	0.35	0.55	0.62
310	0.80	0.00	0.17	0.37	0.59	0.66
320	0.86	0.00	0.18	0.39	0.63	0.70
330	0.91	0.00	0.20	0.42	0.67	0.75
340	0.97	0.00	0.21	0.45	0.71	0.79
350	1.02	0.00	0.22	0.47	0.75	0.84
360	1.08	0.00	0.23	0.50	0.79	0.89
370	1.15	0.00	0.25	0.53	0.84	0.94
380	1.21	0.00	0.26	0.56	0.88	0.99
390	1.27	0.00	0.27	0.59	0.93	1.04
400	1.34	0.00	0.29	0.62	0.98	1.10
410	1.41	0.00	0.30	0.65	1.03	1.15
420	1.48	0.00	0.32	0.68	1.08	1.21
430	1.55	0.00	0.33	0.71	1.13	1.27
440	1.62	0.00	0.35	0.75	1.18	1.33
450	1.69	0.00	0.36	0.78	1.24	1.39
460	1.77	0.00	0.38	0.82	1.29	1.45
470	1.85	0.00	0.40	0.85	1.35	1.52
480	1.93	0.00	0.41	0.89	1.41	1.58
490	2.01	0.00	0.43	0.93	1.47	1.65
500	2.09	0.00	0.45	0.96	1.53	1.72

Table EE80. Area Allowances for **Existing** Hard Hose Traveler Systems
Exterior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **80 percent** of verified wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.19	0.00	0.04	0.09	0.14	0.16
160	0.22	0.00	0.05	0.10	0.16	0.18
170	0.25	0.00	0.05	0.12	0.18	0.20
180	0.28	0.00	0.06	0.13	0.20	0.23
190	0.31	0.00	0.07	0.15	0.23	0.25
200	0.34	0.00	0.08	0.16	0.25	0.28
210	0.38	0.00	0.08	0.18	0.28	0.31
220	0.41	0.00	0.09	0.20	0.30	0.34
230	0.45	0.00	0.10	0.21	0.33	0.37
240	0.49	0.00	0.11	0.23	0.36	0.41
250	0.53	0.00	0.12	0.25	0.39	0.44
260	0.58	0.00	0.13	0.27	0.43	0.48
270	0.62	0.00	0.14	0.29	0.46	0.51
280	0.67	0.00	0.15	0.32	0.49	0.55
290	0.72	0.00	0.16	0.34	0.53	0.59
300	0.77	0.00	0.17	0.36	0.57	0.63
310	0.82	0.00	0.18	0.39	0.60	0.68
320	0.88	0.00	0.19	0.41	0.64	0.72
330	0.93	0.00	0.21	0.44	0.69	0.77
340	0.99	0.00	0.22	0.47	0.73	0.81
350	1.05	0.00	0.23	0.49	0.77	0.86
360	1.11	0.00	0.24	0.52	0.82	0.91
370	1.17	0.00	0.26	0.55	0.86	0.96
380	1.23	0.00	0.27	0.58	0.91	1.02
390	1.30	0.00	0.29	0.61	0.96	1.07
400	1.37	0.00	0.30	0.65	1.01	1.13
410	1.44	0.00	0.32	0.68	1.06	1.18
420	1.51	0.00	0.33	0.71	1.11	1.24
430	1.58	0.00	0.35	0.75	1.16	1.30
440	1.65	0.00	0.37	0.78	1.22	1.36
450	1.73	0.00	0.38	0.82	1.27	1.43
460	1.81	0.00	0.40	0.85	1.33	1.49
470	1.89	0.00	0.42	0.89	1.39	1.56
480	1.97	0.00	0.43	0.93	1.45	1.62
490	2.05	0.00	0.45	0.97	1.51	1.69
500	2.14	0.00	0.47	1.01	1.57	1.76

Table EE85. Area Allowances for **Existing** Hard Hose Traveler Systems
Exterior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **85 percent** of verified wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.20	0.00	0.04	0.09	0.15	0.16
160	0.22	0.00	0.05	0.11	0.17	0.18
170	0.25	0.00	0.06	0.12	0.19	0.21
180	0.28	0.00	0.06	0.14	0.21	0.23
190	0.31	0.00	0.07	0.15	0.23	0.26
200	0.35	0.00	0.08	0.17	0.26	0.29
210	0.38	0.00	0.09	0.19	0.28	0.32
220	0.42	0.00	0.09	0.20	0.31	0.35
230	0.46	0.00	0.10	0.22	0.34	0.38
240	0.50	0.00	0.11	0.24	0.37	0.42
250	0.54	0.00	0.12	0.26	0.40	0.45
260	0.59	0.00	0.13	0.28	0.44	0.49
270	0.63	0.00	0.14	0.31	0.47	0.53
280	0.68	0.00	0.15	0.33	0.51	0.56
290	0.73	0.00	0.16	0.35	0.54	0.61
300	0.78	0.00	0.18	0.38	0.58	0.65
310	0.84	0.00	0.19	0.40	0.62	0.69
320	0.89	0.00	0.20	0.43	0.66	0.74
330	0.95	0.00	0.21	0.46	0.70	0.78
340	1.01	0.00	0.22	0.49	0.75	0.83
350	1.07	0.00	0.24	0.51	0.79	0.88
360	1.13	0.00	0.25	0.54	0.84	0.93
370	1.19	0.00	0.27	0.58	0.88	0.99
380	1.26	0.00	0.28	0.61	0.93	1.04
390	1.32	0.00	0.30	0.64	0.98	1.10
400	1.39	0.00	0.31	0.67	1.03	1.15
410	1.46	0.00	0.33	0.71	1.09	1.21
420	1.54	0.00	0.34	0.74	1.14	1.27
430	1.61	0.00	0.36	0.78	1.19	1.33
440	1.69	0.00	0.38	0.81	1.25	1.40
450	1.76	0.00	0.39	0.85	1.31	1.46
460	1.84	0.00	0.41	0.89	1.37	1.52
470	1.92	0.00	0.43	0.93	1.43	1.59
480	2.01	0.00	0.45	0.97	1.49	1.66
490	2.09	0.00	0.47	1.01	1.55	1.73
500	2.18	0.00	0.49	1.05	1.61	1.80

Table EE90. Area Allowances for **Existing** Hard Hose Traveler Systems
Exterior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **90 percent** of verified wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.20	0.00	0.05	0.10	0.15	0.17
160	0.23	0.00	0.05	0.11	0.17	0.19
170	0.26	0.00	0.06	0.13	0.19	0.21
180	0.29	0.00	0.07	0.14	0.21	0.24
190	0.32	0.00	0.08	0.16	0.24	0.27
200	0.35	0.00	0.08	0.17	0.26	0.29
210	0.39	0.00	0.09	0.19	0.29	0.32
220	0.43	0.00	0.10	0.21	0.32	0.36
230	0.47	0.00	0.11	0.23	0.35	0.39
240	0.51	0.00	0.12	0.25	0.38	0.42
250	0.55	0.00	0.13	0.27	0.41	0.46
260	0.60	0.00	0.14	0.29	0.45	0.50
270	0.64	0.00	0.15	0.32	0.48	0.54
280	0.69	0.00	0.16	0.34	0.52	0.58
290	0.74	0.00	0.18	0.36	0.55	0.62
300	0.80	0.00	0.19	0.39	0.59	0.66
310	0.85	0.00	0.20	0.42	0.63	0.71
320	0.91	0.00	0.21	0.44	0.68	0.75
330	0.96	0.00	0.23	0.47	0.72	0.80
340	1.02	0.00	0.24	0.50	0.76	0.85
350	1.08	0.00	0.26	0.53	0.81	0.90
360	1.15	0.00	0.27	0.56	0.85	0.95
370	1.21	0.00	0.29	0.59	0.90	1.01
380	1.28	0.00	0.30	0.63	0.95	1.06
390	1.35	0.00	0.32	0.66	1.00	1.12
400	1.42	0.00	0.33	0.69	1.06	1.18
410	1.49	0.00	0.35	0.73	1.11	1.23
420	1.56	0.00	0.37	0.77	1.16	1.30
430	1.64	0.00	0.39	0.80	1.22	1.36
440	1.71	0.00	0.40	0.84	1.28	1.42
450	1.79	0.00	0.42	0.88	1.34	1.49
460	1.87	0.00	0.44	0.92	1.40	1.55
470	1.95	0.00	0.46	0.96	1.46	1.62
480	2.04	0.00	0.48	1.00	1.52	1.69
490	2.12	0.00	0.50	1.04	1.58	1.76
500	2.21	0.00	0.52	1.08	1.65	1.84

Table EI60. Area Allowances for **Existing** Hard Hose Traveler Systems
Interior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **60 percent** of verified wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.15	0.00	0.02	0.05	0.09	0.11
160	0.17	0.00	0.02	0.05	0.11	0.13
170	0.19	0.00	0.02	0.06	0.12	0.14
180	0.21	0.00	0.03	0.07	0.14	0.16
190	0.23	0.00	0.03	0.07	0.15	0.18
200	0.26	0.00	0.03	0.08	0.17	0.20
210	0.28	0.00	0.04	0.09	0.18	0.22
220	0.31	0.00	0.04	0.10	0.20	0.24
230	0.34	0.00	0.05	0.11	0.22	0.26
240	0.37	0.00	0.05	0.12	0.24	0.28
250	0.40	0.00	0.05	0.13	0.26	0.31
260	0.44	0.00	0.06	0.14	0.28	0.33
270	0.47	0.00	0.06	0.15	0.31	0.36
280	0.51	0.00	0.07	0.16	0.33	0.39
290	0.54	0.00	0.07	0.17	0.35	0.42
300	0.58	0.00	0.08	0.19	0.38	0.45
310	0.62	0.00	0.08	0.20	0.40	0.48
320	0.66	0.00	0.09	0.21	0.43	0.51
330	0.70	0.00	0.09	0.22	0.46	0.54
340	0.75	0.00	0.10	0.24	0.48	0.57
350	0.79	0.00	0.10	0.25	0.51	0.61
360	0.84	0.00	0.11	0.27	0.54	0.64
370	0.88	0.00	0.12	0.28	0.57	0.68
380	0.93	0.00	0.12	0.30	0.61	0.71
390	0.98	0.00	0.13	0.31	0.64	0.75
400	1.03	0.00	0.14	0.33	0.67	0.79
410	1.08	0.00	0.14	0.35	0.70	0.83
420	1.14	0.00	0.15	0.36	0.74	0.87
430	1.19	0.00	0.16	0.38	0.78	0.91
440	1.25	0.00	0.17	0.40	0.81	0.96
450	1.31	0.00	0.17	0.42	0.85	1.00
460	1.36	0.00	0.18	0.44	0.89	1.05
470	1.42	0.00	0.19	0.46	0.93	1.09
480	1.49	0.00	0.20	0.48	0.97	1.14
490	1.55	0.00	0.21	0.50	1.01	1.19
500	1.61	0.00	0.21	0.52	1.05	1.24

Table EI65. Area Allowances for **Existing** Hard Hose Traveler Systems
Interior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **65 percent** of verified wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.16	0.00	0.02	0.05	0.10	0.12
160	0.18	0.00	0.03	0.06	0.12	0.14
170	0.20	0.00	0.03	0.07	0.13	0.16
180	0.22	0.00	0.03	0.08	0.15	0.17
190	0.25	0.00	0.04	0.09	0.17	0.19
200	0.28	0.00	0.04	0.10	0.19	0.22
210	0.30	0.00	0.04	0.11	0.20	0.24
220	0.33	0.00	0.05	0.12	0.22	0.26
230	0.36	0.00	0.05	0.13	0.25	0.29
240	0.40	0.00	0.06	0.14	0.27	0.31
250	0.43	0.00	0.06	0.15	0.29	0.34
260	0.47	0.00	0.07	0.16	0.31	0.36
270	0.50	0.00	0.07	0.18	0.34	0.39
280	0.54	0.00	0.08	0.19	0.36	0.42
290	0.58	0.00	0.08	0.20	0.39	0.45
300	0.62	0.00	0.09	0.22	0.42	0.49
310	0.66	0.00	0.10	0.23	0.45	0.52
320	0.71	0.00	0.10	0.25	0.48	0.55
330	0.75	0.00	0.11	0.26	0.51	0.59
340	0.80	0.00	0.12	0.28	0.54	0.62
350	0.84	0.00	0.12	0.30	0.57	0.66
360	0.89	0.00	0.13	0.31	0.60	0.70
370	0.94	0.00	0.14	0.33	0.64	0.74
380	1.00	0.00	0.15	0.35	0.67	0.78
390	1.05	0.00	0.15	0.37	0.71	0.82
400	1.10	0.00	0.16	0.39	0.74	0.86
410	1.16	0.00	0.17	0.41	0.78	0.91
420	1.22	0.00	0.18	0.43	0.82	0.95
430	1.27	0.00	0.19	0.45	0.86	1.00
440	1.33	0.00	0.19	0.47	0.90	1.04
450	1.40	0.00	0.20	0.49	0.94	1.09
460	1.46	0.00	0.21	0.51	0.98	1.14
470	1.52	0.00	0.22	0.54	1.03	1.19
480	1.59	0.00	0.23	0.56	1.07	1.24
490	1.66	0.00	0.24	0.58	1.11	1.29
500	1.72	0.00	0.25	0.61	1.16	1.35

Table EI70. Area Allowances for **Existing** Hard Hose Traveler Systems
Interior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **70 percent** of verified wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.16	0.00	0.03	0.06	0.11	0.13
160	0.19	0.00	0.03	0.07	0.13	0.15
170	0.21	0.00	0.03	0.08	0.15	0.17
180	0.24	0.00	0.04	0.09	0.16	0.19
190	0.26	0.00	0.04	0.10	0.18	0.21
200	0.29	0.00	0.05	0.11	0.20	0.23
210	0.32	0.00	0.05	0.12	0.22	0.26
220	0.35	0.00	0.06	0.14	0.25	0.28
230	0.39	0.00	0.06	0.15	0.27	0.31
240	0.42	0.00	0.07	0.16	0.29	0.34
250	0.46	0.00	0.07	0.18	0.32	0.36
260	0.49	0.00	0.08	0.19	0.34	0.39
270	0.53	0.00	0.08	0.20	0.37	0.42
280	0.57	0.00	0.09	0.22	0.40	0.46
290	0.62	0.00	0.10	0.24	0.43	0.49
300	0.66	0.00	0.10	0.25	0.46	0.52
310	0.70	0.00	0.11	0.27	0.49	0.56
320	0.75	0.00	0.12	0.29	0.52	0.60
330	0.80	0.00	0.13	0.31	0.55	0.63
340	0.85	0.00	0.13	0.32	0.59	0.67
350	0.90	0.00	0.14	0.34	0.62	0.71
360	0.95	0.00	0.15	0.36	0.66	0.75
370	1.00	0.00	0.16	0.38	0.69	0.80
380	1.06	0.00	0.17	0.41	0.73	0.84
390	1.11	0.00	0.18	0.43	0.77	0.88
400	1.17	0.00	0.19	0.45	0.81	0.93
410	1.23	0.00	0.20	0.47	0.85	0.98
420	1.29	0.00	0.21	0.50	0.89	1.03
430	1.35	0.00	0.22	0.52	0.94	1.08
440	1.42	0.00	0.23	0.54	0.98	1.13
450	1.48	0.00	0.24	0.57	1.03	1.18
460	1.55	0.00	0.25	0.59	1.07	1.23
470	1.62	0.00	0.26	0.62	1.12	1.28
480	1.69	0.00	0.27	0.65	1.17	1.34
490	1.76	0.00	0.28	0.68	1.22	1.40
500	1.83	0.00	0.29	0.70	1.27	1.45

Table EI75. Area Allowances for **Existing** Hard Hose Traveler Systems
Interior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **75 percent** of verified wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.17	0.00	0.03	0.07	0.12	0.14
160	0.20	0.00	0.03	0.08	0.14	0.16
170	0.22	0.00	0.04	0.09	0.16	0.18
180	0.25	0.00	0.04	0.10	0.18	0.20
190	0.28	0.00	0.05	0.12	0.20	0.22
200	0.31	0.00	0.05	0.13	0.22	0.25
210	0.34	0.00	0.06	0.14	0.24	0.27
220	0.37	0.00	0.06	0.16	0.26	0.30
230	0.41	0.00	0.07	0.17	0.29	0.33
240	0.44	0.00	0.08	0.18	0.31	0.36
250	0.48	0.00	0.08	0.20	0.34	0.39
260	0.52	0.00	0.09	0.22	0.37	0.42
270	0.56	0.00	0.10	0.23	0.40	0.45
280	0.60	0.00	0.10	0.25	0.43	0.49
290	0.65	0.00	0.11	0.27	0.46	0.52
300	0.69	0.00	0.12	0.29	0.49	0.56
310	0.74	0.00	0.13	0.31	0.52	0.60
320	0.79	0.00	0.14	0.33	0.56	0.64
330	0.84	0.00	0.15	0.35	0.59	0.68
340	0.89	0.00	0.15	0.37	0.63	0.72
350	0.94	0.00	0.16	0.39	0.67	0.76
360	1.00	0.00	0.17	0.42	0.71	0.81
370	1.06	0.00	0.18	0.44	0.75	0.85
380	1.11	0.00	0.19	0.46	0.79	0.90
390	1.17	0.00	0.20	0.49	0.83	0.94
400	1.23	0.00	0.21	0.51	0.87	0.99
410	1.30	0.00	0.22	0.54	0.92	1.04
420	1.36	0.00	0.24	0.57	0.96	1.10
430	1.43	0.00	0.25	0.59	1.01	1.15
440	1.49	0.00	0.26	0.62	1.06	1.20
450	1.56	0.00	0.27	0.65	1.11	1.26
460	1.63	0.00	0.28	0.68	1.16	1.31
470	1.70	0.00	0.30	0.71	1.21	1.37
480	1.78	0.00	0.31	0.74	1.26	1.43
490	1.85	0.00	0.32	0.77	1.31	1.49
500	1.93	0.00	0.33	0.80	1.37	1.55

Table EI80. Area Allowances for **Existing** Hard Hose Traveler Systems
Interior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **80 percent** of verified wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.18	0.00	0.03	0.08	0.13	0.15
160	0.21	0.00	0.04	0.09	0.15	0.17
170	0.23	0.00	0.04	0.10	0.17	0.19
180	0.26	0.00	0.05	0.12	0.19	0.21
190	0.29	0.00	0.05	0.13	0.21	0.24
200	0.32	0.00	0.06	0.14	0.23	0.26
210	0.36	0.00	0.07	0.16	0.26	0.29
220	0.39	0.00	0.07	0.17	0.28	0.32
230	0.43	0.00	0.08	0.19	0.31	0.35
240	0.47	0.00	0.09	0.21	0.34	0.38
250	0.50	0.00	0.10	0.22	0.36	0.41
260	0.55	0.00	0.10	0.24	0.39	0.44
270	0.59	0.00	0.11	0.26	0.42	0.48
280	0.63	0.00	0.12	0.28	0.46	0.52
290	0.68	0.00	0.13	0.30	0.49	0.55
300	0.73	0.00	0.14	0.32	0.52	0.59
310	0.78	0.00	0.15	0.34	0.56	0.63
320	0.83	0.00	0.16	0.37	0.60	0.67
330	0.88	0.00	0.17	0.39	0.63	0.72
340	0.93	0.00	0.18	0.41	0.67	0.76
350	0.99	0.00	0.19	0.44	0.71	0.81
360	1.05	0.00	0.20	0.46	0.75	0.85
370	1.11	0.00	0.21	0.49	0.80	0.90
380	1.17	0.00	0.22	0.52	0.84	0.95
390	1.23	0.00	0.23	0.54	0.89	1.00
400	1.29	0.00	0.24	0.57	0.93	1.05
410	1.36	0.00	0.26	0.60	0.98	1.11
420	1.42	0.00	0.27	0.63	1.03	1.16
430	1.49	0.00	0.28	0.66	1.08	1.22
440	1.56	0.00	0.29	0.69	1.13	1.27
450	1.64	0.00	0.31	0.72	1.18	1.33
460	1.71	0.00	0.32	0.76	1.23	1.39
470	1.78	0.00	0.34	0.79	1.29	1.45
480	1.86	0.00	0.35	0.82	1.34	1.51
490	1.94	0.00	0.37	0.86	1.40	1.58
500	2.02	0.00	0.38	0.89	1.46	1.64

Table EI85. Area Allowances for **Existing** Hard Hose Traveler Systems
Interior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **85 percent** of verified wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.19	0.00	0.04	0.09	0.14	0.16
160	0.22	0.00	0.04	0.10	0.16	0.18
170	0.24	0.00	0.05	0.11	0.18	0.20
180	0.27	0.00	0.06	0.13	0.20	0.22
200	0.34	0.00	0.07	0.16	0.25	0.28
210	0.37	0.00	0.08	0.17	0.27	0.30
220	0.41	0.00	0.08	0.19	0.30	0.33
230	0.44	0.00	0.09	0.21	0.33	0.36
240	0.48	0.00	0.10	0.22	0.35	0.40
250	0.53	0.00	0.11	0.24	0.38	0.43
260	0.57	0.00	0.12	0.26	0.42	0.47
270	0.61	0.00	0.13	0.28	0.45	0.50
280	0.66	0.00	0.13	0.31	0.48	0.54
290	0.71	0.00	0.14	0.33	0.52	0.58
300	0.76	0.00	0.15	0.35	0.55	0.62
310	0.81	0.00	0.17	0.37	0.59	0.66
320	0.86	0.00	0.18	0.40	0.63	0.71
330	0.91	0.00	0.19	0.42	0.67	0.75
340	0.97	0.00	0.20	0.45	0.71	0.80
350	1.03	0.00	0.21	0.48	0.75	0.85
360	1.09	0.00	0.22	0.50	0.80	0.89
370	1.15	0.00	0.24	0.53	0.84	0.94
380	1.21	0.00	0.25	0.56	0.89	1.00
390	1.28	0.00	0.26	0.59	0.94	1.05
400	1.34	0.00	0.27	0.62	0.98	1.10
410	1.41	0.00	0.29	0.65	1.03	1.16
420	1.48	0.00	0.30	0.69	1.08	1.22
430	1.55	0.00	0.32	0.72	1.14	1.28
440	1.63	0.00	0.33	0.75	1.19	1.34
450	1.70	0.00	0.35	0.79	1.24	1.40
460	1.78	0.00	0.36	0.82	1.30	1.46
470	1.86	0.00	0.38	0.86	1.36	1.52
480	1.94	0.00	0.40	0.90	1.42	1.59
490	2.02	0.00	0.41	0.93	1.48	1.66
500	2.10	0.00	0.43	0.97	1.54	1.72

Table EI90. Area Allowances for **Existing** Hard Hose Traveler Systems
Interior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **90 percent** of verified wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.20	0.00	0.04	0.09	0.14	0.16
160	0.22	0.00	0.05	0.11	0.16	0.18
170	0.25	0.00	0.06	0.12	0.19	0.21
180	0.28	0.00	0.06	0.14	0.21	0.23
190	0.31	0.00	0.07	0.15	0.23	0.26
200	0.35	0.00	0.08	0.17	0.26	0.29
210	0.38	0.00	0.08	0.18	0.28	0.32
220	0.42	0.00	0.09	0.20	0.31	0.35
230	0.46	0.00	0.10	0.22	0.34	0.38
240	0.50	0.00	0.11	0.24	0.37	0.41
250	0.54	0.00	0.12	0.26	0.40	0.45
260	0.59	0.00	0.13	0.28	0.43	0.49
270	0.63	0.00	0.14	0.30	0.47	0.52
280	0.68	0.00	0.15	0.33	0.50	0.56
290	0.73	0.00	0.16	0.35	0.54	0.60
300	0.78	0.00	0.17	0.38	0.58	0.65
310	0.83	0.00	0.19	0.40	0.62	0.69
320	0.89	0.00	0.20	0.43	0.66	0.73
330	0.95	0.00	0.21	0.45	0.70	0.78
340	1.00	0.00	0.22	0.48	0.74	0.83
350	1.06	0.00	0.24	0.51	0.79	0.88
360	1.12	0.00	0.25	0.54	0.83	0.93
370	1.19	0.00	0.26	0.57	0.88	0.98
380	1.25	0.00	0.28	0.60	0.93	1.04
390	1.32	0.00	0.29	0.63	0.98	1.09
400	1.39	0.00	0.31	0.67	1.03	1.15
410	1.46	0.00	0.32	0.70	1.08	1.21
420	1.53	0.00	0.34	0.74	1.13	1.27
430	1.60	0.00	0.36	0.77	1.19	1.33
440	1.68	0.00	0.37	0.81	1.24	1.39
450	1.76	0.00	0.39	0.84	1.30	1.45
460	1.84	0.00	0.41	0.88	1.36	1.52
470	1.92	0.00	0.43	0.92	1.42	1.59
480	2.00	0.00	0.44	0.96	1.48	1.65
490	2.08	0.00	0.46	1.00	1.54	1.72
500	2.17	0.00	0.48	1.04	1.61	1.79

Table E90+. Area Allowances for **Existing** Hard Hose Traveler Systems
Fields with **single pull** or **multiple pulls** and
Hydrant spacing **greater than 90 percent** of verified wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.16	0.00	0.04	0.08	0.12	0.14
160	0.19	0.00	0.05	0.09	0.14	0.16
170	0.21	0.00	0.05	0.11	0.16	0.18
180	0.24	0.00	0.06	0.12	0.18	0.20
190	0.26	0.00	0.07	0.13	0.20	0.22
200	0.29	0.00	0.07	0.15	0.22	0.24
210	0.32	0.00	0.08	0.16	0.24	0.27
220	0.35	0.00	0.09	0.18	0.27	0.29
230	0.39	0.00	0.10	0.19	0.29	0.32
240	0.42	0.00	0.11	0.21	0.32	0.35
250	0.46	0.00	0.11	0.23	0.34	0.38
260	0.49	0.00	0.12	0.25	0.37	0.41
270	0.53	0.00	0.13	0.27	0.40	0.44
280	0.57	0.00	0.14	0.29	0.43	0.48
290	0.61	0.00	0.15	0.31	0.46	0.51
300	0.66	0.00	0.16	0.33	0.49	0.55
310	0.70	0.00	0.18	0.35	0.53	0.58
320	0.75	0.00	0.19	0.37	0.56	0.62
330	0.80	0.00	0.20	0.40	0.60	0.66
340	0.84	0.00	0.21	0.42	0.63	0.70
350	0.89	0.00	0.22	0.45	0.67	0.75
360	0.95	0.00	0.24	0.47	0.71	0.79
370	1.00	0.00	0.25	0.50	0.75	0.83
380	1.05	0.00	0.26	0.53	0.79	0.88
390	1.11	0.00	0.28	0.56	0.83	0.93
400	1.17	0.00	0.29	0.58	0.88	0.97
410	1.23	0.00	0.31	0.61	0.92	1.02
420	1.29	0.00	0.32	0.64	0.97	1.07
430	1.35	0.00	0.34	0.68	1.01	1.13
440	1.41	0.00	0.35	0.71	1.06	1.18
450	1.48	0.00	0.37	0.74	1.11	1.23
460	1.55	0.00	0.39	0.77	1.16	1.29
470	1.61	0.00	0.40	0.81	1.21	1.34
480	1.68	0.00	0.42	0.84	1.26	1.40
490	1.75	0.00	0.44	0.88	1.32	1.46
500	1.83	0.00	0.46	0.91	1.37	1.52

Table NE60. Area Allowances for **New or Expanded** Hard Hose Traveler Systems
Exterior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **60 percent** of wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.12	0.00	0.03	0.05	0.08	0.09
160	0.13	0.00	0.03	0.06	0.10	0.11
170	0.15	0.00	0.03	0.07	0.11	0.12
180	0.17	0.00	0.04	0.08	0.12	0.14
190	0.19	0.00	0.04	0.09	0.14	0.15
200	0.21	0.00	0.04	0.10	0.15	0.17
210	0.23	0.00	0.05	0.11	0.17	0.19
220	0.25	0.00	0.05	0.12	0.18	0.20
230	0.27	0.00	0.06	0.13	0.20	0.22
240	0.30	0.00	0.06	0.14	0.22	0.24
250	0.32	0.00	0.07	0.15	0.24	0.26
260	0.35	0.00	0.08	0.16	0.25	0.29
270	0.37	0.00	0.08	0.17	0.27	0.31
280	0.40	0.00	0.09	0.19	0.29	0.33
290	0.43	0.00	0.09	0.20	0.32	0.35
300	0.46	0.00	0.10	0.22	0.34	0.38
310	0.49	0.00	0.11	0.23	0.36	0.41
320	0.53	0.00	0.11	0.24	0.39	0.43
330	0.56	0.00	0.12	0.26	0.41	0.46
340	0.59	0.00	0.13	0.28	0.43	0.49
350	0.63	0.00	0.14	0.29	0.46	0.52
360	0.67	0.00	0.14	0.31	0.49	0.55
370	0.70	0.00	0.15	0.33	0.51	0.58
380	0.74	0.00	0.16	0.35	0.54	0.61
390	0.78	0.00	0.17	0.36	0.57	0.64
400	0.82	0.00	0.18	0.38	0.60	0.68
410	0.86	0.00	0.19	0.40	0.63	0.71
420	0.91	0.00	0.20	0.42	0.66	0.74
430	0.95	0.00	0.21	0.44	0.70	0.78
440	0.99	0.00	0.22	0.46	0.73	0.82
450	1.04	0.00	0.23	0.48	0.76	0.85
460	1.09	0.00	0.24	0.51	0.80	0.89
470	1.13	0.00	0.25	0.53	0.83	0.93
480	1.18	0.00	0.26	0.55	0.87	0.97
490	1.23	0.00	0.27	0.57	0.90	1.01
500	1.28	0.00	0.28	0.60	0.94	1.05

Table NE65. Area Allowances for **New or Expanded** Hard Hose Traveler Systems
Exterior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **65 percent** of wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.12	0.00	0.03	0.06	0.09	0.10
160	0.13	0.00	0.03	0.06	0.10	0.11
170	0.15	0.00	0.03	0.07	0.11	0.13
180	0.17	0.00	0.04	0.08	0.13	0.14
190	0.19	0.00	0.04	0.09	0.14	0.16
200	0.21	0.00	0.05	0.10	0.16	0.17
210	0.23	0.00	0.05	0.11	0.17	0.19
220	0.25	0.00	0.06	0.12	0.19	0.21
230	0.28	0.00	0.06	0.13	0.21	0.23
240	0.30	0.00	0.07	0.15	0.22	0.25
250	0.33	0.00	0.07	0.16	0.24	0.27
260	0.36	0.00	0.08	0.17	0.26	0.29
270	0.38	0.00	0.09	0.18	0.28	0.32
280	0.41	0.00	0.09	0.20	0.31	0.34
290	0.44	0.00	0.10	0.21	0.33	0.37
300	0.47	0.00	0.11	0.23	0.35	0.39
310	0.51	0.00	0.11	0.24	0.37	0.42
320	0.54	0.00	0.12	0.26	0.40	0.45
330	0.57	0.00	0.13	0.27	0.42	0.47
340	0.61	0.00	0.14	0.29	0.45	0.50
350	0.65	0.00	0.15	0.31	0.48	0.53
360	0.68	0.00	0.15	0.33	0.50	0.56
370	0.72	0.00	0.16	0.35	0.53	0.60
380	0.76	0.00	0.17	0.36	0.56	0.63
390	0.80	0.00	0.18	0.38	0.59	0.66
400	0.84	0.00	0.19	0.40	0.62	0.70
410	0.89	0.00	0.20	0.42	0.65	0.73
420	0.93	0.00	0.21	0.45	0.69	0.77
430	0.97	0.00	0.22	0.47	0.72	0.80
440	1.02	0.00	0.23	0.49	0.75	0.84
450	1.07	0.00	0.24	0.51	0.79	0.88
460	1.11	0.00	0.25	0.53	0.82	0.92
470	1.16	0.00	0.26	0.56	0.86	0.96
480	1.21	0.00	0.27	0.58	0.90	1.00
490	1.26	0.00	0.29	0.61	0.94	1.05
500	1.32	0.00	0.30	0.63	0.97	1.09

Table NE70. Area Allowances for **New or Expanded** Hard Hose Traveler Systems
Exterior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **70 percent** of wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.12	0.00	0.03	0.06	0.09	0.10
160	0.14	0.00	0.03	0.07	0.10	0.11
170	0.16	0.00	0.04	0.08	0.12	0.13
180	0.17	0.00	0.04	0.09	0.13	0.14
190	0.19	0.00	0.05	0.10	0.14	0.16
200	0.22	0.00	0.05	0.11	0.16	0.18
210	0.24	0.00	0.06	0.12	0.18	0.20
220	0.26	0.00	0.06	0.13	0.19	0.22
230	0.28	0.00	0.07	0.14	0.21	0.24
240	0.31	0.00	0.07	0.15	0.23	0.26
250	0.34	0.00	0.08	0.16	0.25	0.28
260	0.36	0.00	0.09	0.18	0.27	0.30
270	0.39	0.00	0.09	0.19	0.29	0.33
280	0.42	0.00	0.10	0.21	0.31	0.35
290	0.45	0.00	0.11	0.22	0.34	0.38
300	0.48	0.00	0.11	0.24	0.36	0.40
310	0.52	0.00	0.12	0.25	0.39	0.43
320	0.55	0.00	0.13	0.27	0.41	0.46
330	0.59	0.00	0.14	0.29	0.44	0.49
340	0.62	0.00	0.15	0.30	0.46	0.52
350	0.66	0.00	0.16	0.32	0.49	0.55
360	0.70	0.00	0.16	0.34	0.52	0.58
370	0.74	0.00	0.17	0.36	0.55	0.61
380	0.78	0.00	0.18	0.38	0.58	0.64
390	0.82	0.00	0.19	0.40	0.61	0.68
400	0.86	0.00	0.20	0.42	0.64	0.71
410	0.90	0.00	0.21	0.44	0.67	0.75
420	0.95	0.00	0.22	0.46	0.71	0.79
430	0.99	0.00	0.23	0.49	0.74	0.83
440	1.04	0.00	0.25	0.51	0.78	0.86
450	1.09	0.00	0.26	0.53	0.81	0.90
460	1.14	0.00	0.27	0.56	0.85	0.94
470	1.19	0.00	0.28	0.58	0.89	0.99
480	1.24	0.00	0.29	0.61	0.92	1.03
490	1.29	0.00	0.30	0.63	0.96	1.07
500	1.34	0.00	0.32	0.66	1.00	1.12

Table NE75. Area Allowances for **New or Expanded** Hard Hose Traveler Systems
Exterior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **75 percent** of wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.12	0.00	0.03	0.06	0.09	0.10
160	0.14	0.00	0.03	0.07	0.10	0.12
170	0.16	0.00	0.04	0.08	0.12	0.13
180	0.18	0.00	0.04	0.09	0.13	0.15
190	0.20	0.00	0.05	0.10	0.15	0.16
200	0.22	0.00	0.05	0.11	0.16	0.18
210	0.24	0.00	0.06	0.12	0.18	0.20
220	0.26	0.00	0.07	0.13	0.20	0.22
230	0.29	0.00	0.07	0.14	0.22	0.24
240	0.31	0.00	0.08	0.16	0.24	0.26
250	0.34	0.00	0.08	0.17	0.26	0.28
260	0.37	0.00	0.09	0.18	0.28	0.31
270	0.40	0.00	0.10	0.20	0.30	0.33
280	0.43	0.00	0.11	0.21	0.32	0.36
290	0.46	0.00	0.11	0.23	0.34	0.38
300	0.49	0.00	0.12	0.24	0.37	0.41
310	0.52	0.00	0.13	0.26	0.39	0.44
320	0.56	0.00	0.14	0.28	0.42	0.47
330	0.59	0.00	0.15	0.30	0.45	0.50
340	0.63	0.00	0.16	0.31	0.47	0.53
350	0.67	0.00	0.16	0.33	0.50	0.56
360	0.71	0.00	0.17	0.35	0.53	0.59
370	0.75	0.00	0.18	0.37	0.56	0.62
380	0.79	0.00	0.19	0.39	0.59	0.66
390	0.83	0.00	0.20	0.41	0.62	0.69
400	0.87	0.00	0.22	0.43	0.65	0.73
410	0.92	0.00	0.23	0.46	0.69	0.76
420	0.96	0.00	0.24	0.48	0.72	0.80
430	1.01	0.00	0.25	0.50	0.76	0.84
440	1.06	0.00	0.26	0.53	0.79	0.88
450	1.11	0.00	0.27	0.55	0.83	0.92
460	1.16	0.00	0.28	0.58	0.87	0.96
470	1.21	0.00	0.30	0.60	0.90	1.00
480	1.26	0.00	0.31	0.63	0.94	1.05
490	1.31	0.00	0.32	0.65	0.98	1.09
500	1.37	0.00	0.34	0.68	1.02	1.14

Table NI60. Area Allowances for **New or Expanded** Hard Hose Traveler Systems
Interior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **60 percent** of wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.11	0.00	0.02	0.05	0.08	0.09
160	0.12	0.00	0.02	0.05	0.09	0.10
170	0.14	0.00	0.02	0.06	0.10	0.11
180	0.15	0.00	0.03	0.07	0.11	0.13
190	0.17	0.00	0.03	0.07	0.12	0.14
200	0.19	0.00	0.03	0.08	0.14	0.15
210	0.21	0.00	0.04	0.09	0.15	0.17
220	0.23	0.00	0.04	0.10	0.17	0.19
230	0.25	0.00	0.05	0.11	0.18	0.20
240	0.28	0.00	0.05	0.12	0.20	0.22
250	0.30	0.00	0.05	0.13	0.21	0.24
260	0.32	0.00	0.06	0.14	0.23	0.26
270	0.35	0.00	0.06	0.15	0.25	0.28
280	0.37	0.00	0.07	0.16	0.27	0.30
290	0.40	0.00	0.07	0.17	0.29	0.33
300	0.43	0.00	0.08	0.18	0.31	0.35
310	0.46	0.00	0.08	0.20	0.33	0.37
320	0.49	0.00	0.09	0.21	0.35	0.40
330	0.52	0.00	0.09	0.22	0.37	0.42
340	0.55	0.00	0.10	0.24	0.39	0.45
350	0.59	0.00	0.10	0.25	0.42	0.47
360	0.62	0.00	0.11	0.26	0.44	0.50
370	0.65	0.00	0.12	0.28	0.47	0.53
380	0.69	0.00	0.12	0.29	0.49	0.56
390	0.73	0.00	0.13	0.31	0.52	0.59
400	0.76	0.00	0.14	0.33	0.55	0.62
410	0.80	0.00	0.14	0.34	0.57	0.65
420	0.84	0.00	0.15	0.36	0.60	0.68
430	0.88	0.00	0.16	0.38	0.63	0.71
440	0.93	0.00	0.17	0.39	0.66	0.75
450	0.97	0.00	0.17	0.41	0.69	0.78
460	1.01	0.00	0.18	0.43	0.72	0.82
470	1.06	0.00	0.19	0.45	0.75	0.85
480	1.10	0.00	0.20	0.47	0.79	0.89
490	1.15	0.00	0.21	0.49	0.82	0.93
500	1.20	0.00	0.21	0.51	0.85	0.97

Table NI65. Area Allowances for **New or Expanded** Hard Hose Traveler Systems
Interior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **65 percent** of wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.11	0.00	0.02	0.05	0.08	0.09
160	0.13	0.00	0.03	0.06	0.09	0.11
170	0.15	0.00	0.03	0.07	0.11	0.12
180	0.16	0.00	0.03	0.07	0.12	0.13
190	0.18	0.00	0.04	0.08	0.13	0.15
200	0.20	0.00	0.04	0.09	0.15	0.17
210	0.22	0.00	0.04	0.10	0.16	0.18
220	0.24	0.00	0.05	0.11	0.18	0.20
230	0.27	0.00	0.05	0.12	0.19	0.22
240	0.29	0.00	0.06	0.13	0.21	0.24
250	0.32	0.00	0.06	0.14	0.23	0.26
260	0.34	0.00	0.07	0.16	0.25	0.28
270	0.37	0.00	0.07	0.17	0.27	0.30
280	0.40	0.00	0.08	0.18	0.29	0.32
290	0.42	0.00	0.08	0.19	0.31	0.35
300	0.45	0.00	0.09	0.21	0.33	0.37
310	0.49	0.00	0.10	0.22	0.35	0.40
320	0.52	0.00	0.10	0.24	0.38	0.42
330	0.55	0.00	0.11	0.25	0.40	0.45
340	0.58	0.00	0.12	0.27	0.43	0.48
350	0.62	0.00	0.12	0.28	0.45	0.51
360	0.65	0.00	0.13	0.30	0.48	0.54
370	0.69	0.00	0.14	0.32	0.50	0.57
380	0.73	0.00	0.15	0.33	0.53	0.60
390	0.77	0.00	0.15	0.35	0.56	0.63
400	0.81	0.00	0.16	0.37	0.59	0.66
410	0.85	0.00	0.17	0.39	0.62	0.69
420	0.89	0.00	0.18	0.41	0.65	0.73
430	0.93	0.00	0.19	0.43	0.68	0.76
440	0.98	0.00	0.19	0.45	0.71	0.80
450	1.02	0.00	0.20	0.47	0.74	0.84
460	1.07	0.00	0.21	0.49	0.78	0.87
470	1.12	0.00	0.22	0.51	0.81	0.91
480	1.16	0.00	0.23	0.53	0.85	0.95
490	1.21	0.00	0.24	0.55	0.88	0.99
500	1.26	0.00	0.25	0.58	0.92	1.03

Table NI70. Area Allowances for **New or Expanded** Hard Hose Traveler Systems
Interior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **70 percent** of wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.12	0.00	0.03	0.06	0.09	0.10
160	0.13	0.00	0.03	0.06	0.10	0.11
170	0.15	0.00	0.03	0.07	0.11	0.13
180	0.17	0.00	0.04	0.08	0.13	0.14
190	0.19	0.00	0.04	0.09	0.14	0.16
200	0.21	0.00	0.05	0.10	0.16	0.17
210	0.23	0.00	0.05	0.11	0.17	0.19
220	0.26	0.00	0.06	0.12	0.19	0.21
230	0.28	0.00	0.06	0.13	0.21	0.23
240	0.30	0.00	0.07	0.15	0.22	0.25
250	0.33	0.00	0.07	0.16	0.24	0.27
260	0.36	0.00	0.08	0.17	0.26	0.29
270	0.38	0.00	0.08	0.18	0.28	0.32
280	0.41	0.00	0.09	0.20	0.31	0.34
290	0.44	0.00	0.10	0.21	0.33	0.37
300	0.47	0.00	0.10	0.23	0.35	0.39
310	0.51	0.00	0.11	0.24	0.37	0.42
320	0.54	0.00	0.12	0.26	0.40	0.45
330	0.57	0.00	0.13	0.28	0.42	0.47
340	0.61	0.00	0.13	0.29	0.45	0.50
350	0.65	0.00	0.14	0.31	0.48	0.53
360	0.68	0.00	0.15	0.33	0.51	0.56
370	0.72	0.00	0.16	0.35	0.53	0.60
380	0.76	0.00	0.17	0.37	0.56	0.63
390	0.80	0.00	0.18	0.38	0.59	0.66
400	0.84	0.00	0.19	0.40	0.62	0.70
410	0.89	0.00	0.20	0.43	0.66	0.73
420	0.93	0.00	0.21	0.45	0.69	0.77
430	0.97	0.00	0.22	0.47	0.72	0.81
440	1.02	0.00	0.23	0.49	0.76	0.84
450	1.07	0.00	0.24	0.51	0.79	0.88
460	1.12	0.00	0.25	0.54	0.83	0.92
470	1.16	0.00	0.26	0.56	0.86	0.96
480	1.21	0.00	0.27	0.58	0.90	1.00
490	1.27	0.00	0.28	0.61	0.94	1.05
500	1.32	0.00	0.29	0.63	0.98	1.09

Table NI75. Area Allowances for **New or Expanded** Hard Hose Traveler Systems
Interior lane in fields with multiple overlapping lanes:
Hydrant spacing based on **75 percent** of wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.12	0.00	0.03	0.06	0.09	0.10
160	0.14	0.00	0.03	0.07	0.10	0.12
170	0.16	0.00	0.04	0.08	0.12	0.13
180	0.18	0.00	0.04	0.09	0.13	0.15
190	0.20	0.00	0.05	0.10	0.15	0.16
200	0.22	0.00	0.05	0.11	0.16	0.18
210	0.24	0.00	0.06	0.12	0.18	0.20
220	0.26	0.00	0.06	0.13	0.20	0.22
230	0.29	0.00	0.07	0.14	0.22	0.24
240	0.31	0.00	0.08	0.16	0.23	0.26
250	0.34	0.00	0.08	0.17	0.25	0.28
260	0.37	0.00	0.09	0.18	0.27	0.31
270	0.40	0.00	0.10	0.20	0.30	0.33
280	0.43	0.00	0.10	0.21	0.32	0.35
290	0.46	0.00	0.11	0.23	0.34	0.38
300	0.49	0.00	0.12	0.24	0.37	0.41
310	0.52	0.00	0.13	0.26	0.39	0.43
320	0.56	0.00	0.14	0.28	0.42	0.46
330	0.59	0.00	0.14	0.29	0.44	0.49
340	0.63	0.00	0.15	0.31	0.47	0.52
350	0.67	0.00	0.16	0.33	0.50	0.55
360	0.70	0.00	0.17	0.35	0.53	0.59
370	0.74	0.00	0.18	0.37	0.56	0.62
380	0.78	0.00	0.19	0.39	0.59	0.65
390	0.83	0.00	0.20	0.41	0.62	0.69
400	0.87	0.00	0.21	0.43	0.65	0.72
410	0.91	0.00	0.22	0.45	0.68	0.76
420	0.96	0.00	0.23	0.48	0.72	0.80
430	1.01	0.00	0.24	0.50	0.75	0.84
440	1.05	0.00	0.26	0.52	0.79	0.88
450	1.10	0.00	0.27	0.55	0.82	0.92
460	1.15	0.00	0.28	0.57	0.86	0.96
470	1.20	0.00	0.29	0.59	0.90	1.00
480	1.25	0.00	0.30	0.62	0.94	1.04
490	1.31	0.00	0.32	0.65	0.98	1.09
500	1.36	0.00	0.33	0.67	1.02	1.13

Table N75+. Area Allowances for **New or Expanded** Hard Hose Traveler Systems
Exterior or Interior lane in fields with single pull or:
Hydrant spacing greater than **75 percent** of wetted diameter
(Acreage is outside starting/stopping gun location)

wetted diameter d (feet)	start end wetted area (acres)	stop end wetted area (acres)				
		arc angle 180 degrees	arc angle 225 degrees	arc angle 270 degrees	arc angle 315 degrees	arc angle 330 degrees
(A)	(B)	(C)	(D)	(E)	(F)	(G)
150	0.12	0.00	0.03	0.06	0.09	0.10
160	0.14	0.00	0.04	0.07	0.11	0.12
170	0.16	0.00	0.04	0.08	0.12	0.13
180	0.18	0.00	0.04	0.09	0.13	0.15
190	0.20	0.00	0.05	0.10	0.15	0.17
200	0.22	0.00	0.05	0.11	0.16	0.18
210	0.24	0.00	0.06	0.12	0.18	0.20
220	0.27	0.00	0.07	0.13	0.20	0.22
230	0.29	0.00	0.07	0.15	0.22	0.24
240	0.32	0.00	0.08	0.16	0.24	0.26
250	0.34	0.00	0.09	0.17	0.26	0.29
260	0.37	0.00	0.09	0.19	0.28	0.31
270	0.40	0.00	0.10	0.20	0.30	0.33
280	0.43	0.00	0.11	0.22	0.32	0.36
290	0.46	0.00	0.12	0.23	0.35	0.38
300	0.49	0.00	0.12	0.25	0.37	0.41
310	0.53	0.00	0.13	0.26	0.40	0.44
320	0.56	0.00	0.14	0.28	0.42	0.47
330	0.60	0.00	0.15	0.30	0.45	0.50
340	0.63	0.00	0.16	0.32	0.48	0.53
350	0.67	0.00	0.17	0.34	0.50	0.56
360	0.71	0.00	0.18	0.36	0.53	0.59
370	0.75	0.00	0.19	0.38	0.56	0.63
380	0.79	0.00	0.20	0.40	0.59	0.66
390	0.83	0.00	0.21	0.42	0.63	0.70
400	0.88	0.00	0.22	0.44	0.66	0.73
410	0.92	0.00	0.23	0.46	0.69	0.77
420	0.97	0.00	0.24	0.48	0.73	0.81
430	1.01	0.00	0.25	0.51	0.76	0.85
440	1.06	0.00	0.27	0.53	0.80	0.88
450	1.11	0.00	0.28	0.56	0.83	0.93
460	1.16	0.00	0.29	0.58	0.87	0.97
470	1.21	0.00	0.30	0.61	0.91	1.01
480	1.26	0.00	0.32	0.63	0.95	1.05
490	1.32	0.00	0.33	0.66	0.99	1.10
500	1.37	0.00	0.34	0.69	1.03	1.14

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