TECHNICAL NOTES

ENGINEERING TECHNICAL NOTE OK-13 **February 1, 2012**

TO: All Offices

FROM: J. Chris Stoner, PE
State Conservation Engineer

RE: Revised Guide for Planning and Design Criteria for Dry Hydrants
August 1992; Revised February 2012

General

In 1984, Insurance Service Organization (ISO) first acknowledged the use of a shuttle water supply in providing grades for insurance premium rates. This allowed the use of dry hydrants. The installation of a system of dry hydrants may result in reduced ISO grading which may result in reduced insurance premiums for the area the dry hydrants serve. Other individuals or communities may be interested in installing dry hydrants for their own convenience or protection even though it would not affect their insurance rates, unless their insurance company gives a discount independently.

Refer to Oklahoma Conservation Practice Standard 432 – Dry Hydrant for design criteria and considerations in the planning and design of dry hydrants. Planning and design of dry hydrants requires the close cooperation of the local fire department and the landowner. For each dry hydrant, the local fire department should concur in the following:

- Dry hydrant location
- Site specifics at location
- Access roads are durable and sufficient to hold a fire truck
- Safety of road and line-of-site is adequate
- Type of pipe and fittings
- Fittings are compatible with the fire truck system
- Design of installation
- Additional local requirements

Water Supply

The reliability of an impounded water supply, tank, or storage facility is the minimum quantity available (at not over 15-ft lift) during a drought with an average 50-year frequency (certified by a registered professional engineer). Oklahoma Conservation Practice Standard 432 - Dry Hydrant requires the use of *Reservoir Operation Study Computer Program* (TR-19, RESOP) or other similar computer programs or models to determine the volume of water supply in water impoundment structures. Oklahoma NRCS developed this technical note to be used as a tool for planning and design of dry hydrants. Use of this technical note will be considered a suitable tool and design procedure to determine the volume of water supply in a water impoundment structures to be used as a source of water for a dry hydrant.

The maximum rate of flow is determined by testing using the pumper(s), hose arrangement, and dry hydrant normally used at this site. The minimum required flow rate is 250 gpm without interruption for 2 hours, within 5 minutes of the arrival of the first apparatus (30,000 gallons / 4000 cubic feet / 1.1 acre inches).

Further, the reliability of a supply from a flowing stream is the minimum rate of flow during a drought with an average 50-year frequency (certified by a registered professional engineer). The maximum rate of flow is determined by testing using the pumper(s), hose arrangement, and dry hydrant normally used at this site. The minimum flow rate is 250 gpm without interruption for 2 hours, within 5 minutes of arrival of the first apparatus.

The minimum quantity of water required must be available 365 days a year and provide pumpable impounded water at all times. If a community uses a dry hydrant or suction supply point, the Insurance Services Office (ISO) may need certification of the water capacity available during a 50-year drought cycle.

Oklahoma NRCS will use the procedure in this guide for design and Standard Drawing OK-DWG-No. 500 Dry Hydrant - Pond to certify the practice meets the Oklahoma Conservation Practice Standard 432 - Dry Hydrant. Certification by a registered professional engineer will not be required to meet the practice standard.

The adequacy of the water supply from impoundments shall be determined by one of the following methods:

1. The pond shall meet the minimum conditions shown in Figures 1, 2, and 3 found in Appendix 2.

2. The 50-year frequency drought level may be approximated by subtracting the following volume from the normal permanent pool level:

   Twice the average annual lake evaporation less one-half the net annual runoff

3. A detailed site specific hydrologic analysis using RESOP or other similar computer programs or models shall be made to determine the minimum water available during a drought with an average 50-year frequency.

Method 1

Figures 1, 2, and 3 are provided to determine the minimum requirements for a site to meet criteria approximating the above NFPA 1231 requirements for an impoundment type structure. For example, a site in central Oklahoma County must meet all of the following:

Figure 1	1.0 acre surface area
Figure 2	8.2 feet minimum depth
Figure 3	20 acres drainage area - no "A" group soils

Then, pipe intake depth would be a minimum of 6.2 feet below the permanent pool (8.2 feet less 2.0 feet above pond bottom).

Method 2

1. This method utilizes Figure No. 4 (Average Annual Runoff) and Figure No. 5 (Net Lake Evaporation) found in Appendix 2.

The volume of recharge to the pond (where a dry hydrant is proposed) is computed as 1/2 the average annual runoff shown in Figure 4 times the acres of drainage area. This volume is reduced by twice the net lake evaporation (losses) from Figure 5 for a particular surface area of the pond.

The resultant figure is subtracted from the storage in the structure between normal pool and two feet above intake level (four feet above pond bottom). The resultant figure shall exceed 30,000 gallons (1.1 acre inches).

By definition, when the computed losses equal 1/2 of the annual inflow, this volume represents the 50-yr drought. Further, the 50-yr drought pool can be calculated from a basin plotting of elevation vs. surface area and elevation vs. storage (acre-feet). Begin at a point 4 feet above bottom of pond plus 30,000 gallons (4'+0.09 Ac Ft) or use pipe intake elevation plus 2 feet plus 30,000 gallons (whichever is higher) for the bottom elevation of the drought pool. Add the losses due to evaporation (twice the average net lake evaporation) expressed as acre feet to determine top of the 50-yr drought pool. Further, a special design may be made to take credit for base flow (spring flow) and for pit-type impoundments for those sites not meeting criteria for Method 1.

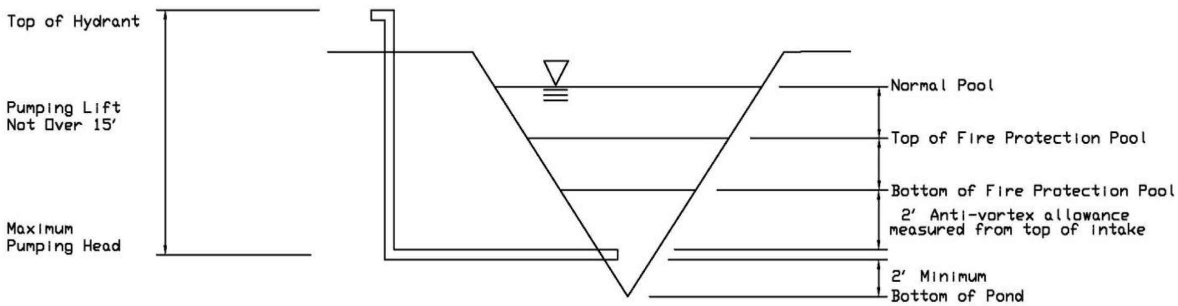
Also, this procedure does not take into account seepage through the embankment and abutments. Sites in sandy areas should be avoided except for those which can be justified on base flow or high water tables.

Method 3

This method involves completing a water budget for the structure using RESOP or other similar computer programs or models. It requires detailed basin surveys, hydrologic data, hydraulic data, and a computer program to interject weather data into the storage and runoff computations.

All Methods

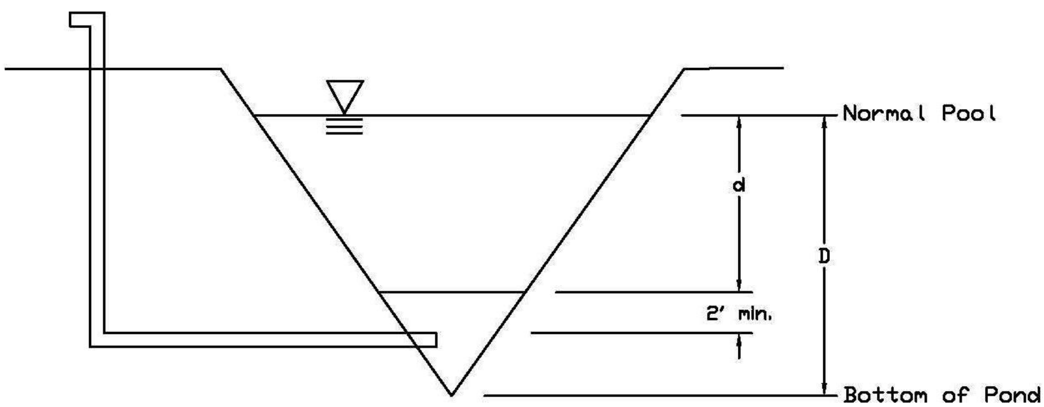
The schematic below provides an overview for water supply needs and terms in accordance with Oklahoma Conservation Practice Standard 432 - Dry Hydrant. Water usage for irrigation, livestock water, crop spraying, and other related uses, as well as known or estimated seepage losses, should be subtracted from the normal pool level. Sites known to have periodically gone dry shall not be used.



Sketch No. 1 – Typical Water Supply Impoundment Cross Sectional Sketch

<u>Estimate of Available Water Supply at Normal Pool</u>

In lieu of a basin survey, Figure 6 may be used to make estimates for storage volumes when the surface area in acres and depth in feet is known. Figure 6 has an example estimating total storage in acre feet and gallons for the depth 2 feet above the pipe intake to normal pool elevation. One curve is for a basin in a "U"-shaped valley and the other for a "V"-shape embankment or pyramidal impoundment. Figure 6 can be found in Appendix 2.



D = Total depth from normal pool to bottom of pond
d = Depth from normal pool to bottom of fire protection pool (2 'above centerline of intake)
A_{NP} = Surface area at normal pool elevation
A_{BFP} = Surface area at bottom of fire protection pool (2 'above centerline of intake)
Percent of Maximum Depth = (100 – d/D)/100
Available water volume = d [(A_{NP} + A_{BFP})/2]

Sketch No. 2 - Typical Cross Sectional Sketch

EXAMPLE using Figure No. 6:

Pond with "U" shaped valley
Surface Area (A_{NP}) = 4 acres
D = 16 ft.
Pipe intake will be located at 11.6 ft below normal pool

Percent of Maximum Depth = (100 – d/D)/100 = (100 – ((11.6 – 2)/16)) = 40 percent

Enter graph at 40 percent of maximum depth, go up to applicable curve and left to read factor = 25 percent (0.25) of maximum surface area. Multiply total area in acres (A_{NP}) by factor to get surface area at bottom of fire protection pool (A_{BFP}).

Available water volume = d [(A_{NP} + A_{BFP})/2] = 9.6 [(4 + (4 x 0.25))/2] = 24 Ac Ft
Available water volume = 24 X 43,560 X 7.48 = 7,800,000 gallons
(Note: this is the total amount of water available when the pond water level is located at normal pool elevation.)

Intake Strainer Details

To avoid a vortex or whirlpool during pumping, the top of the inlet pipe shall be at least 2.0' below the 50-year drought elevation plus 30,000 gallons storage for firefighting purposes unless a special design is prepared to eliminate the vortex. The vortex allows air to enter the pump which decreases pump capacity and may cause the pump to lose prime.

Special designs may include installation of an anti-vortex baffle, anti-swirl plates or the top of the pipe may be left solid (without holes). See Table No. 1 below to determine:

- The top width in inches to leave solid if needed to provide anti-vortex protection.
- The minimum number of holes by diameter (1/4", 5/16", and 3/8") needed to give four times the open area for the pipe size diameter being used.
- The minimum perforated pipe length needed.

Table 1 Intake Strainer Details - Number of Holes Needed for 4 Times Area of Pipe

	Hole Size in Inches				
Pipe Size Inches Diameter	0.25 1/4	0.3125 5/16	0.375 3/8	Minimum Length Feet *	Top Width Solid Inches **
6	2303	1475	1024	3.4	4
8	4096	2621	1820	4.6	6
10	6400	4096	2844	5.6	7
12	9216	5898	4096	6.6	8

* Based on hole spacing = 2 hole diameters minimum.
** No holes in top portion of pipe for distance shown to counter anti-vortex forces.

Shop built strainers shall have the holes deburred and smoothed so that flow through the holes (orifices) are not impeded and prevents the chips from coming loose to clog the openings of the strainer in the hydrant head or get into the fire truck pump.

Holes larger than 3/8" diameter are not recommended as minnows will enter, grow, and cannot get back out. Where silt or other minute particles are a concern, commercial well screens should be recommended. Also, manufactured strainers meeting National Fire Protection Association codes and standards are now available.

It is recommended that the intake strainer end cap also be perforated to improve intake flow characteristics. Also, a pinned or snap-in cap is preferred to a hinged cap. Their performance on back-flushing is superior to the hinged cap.The perforations assist in flushing silt away from the intake, if necessary.

Hydraulic Design

Since it is the flow rate delivered which controls fire suppression, or the lack of it that allows fire to burn uncontrolled, pump flow should not be restricted by having too much head loss from suction line and connectors. Regardless of the capacity of the (truck) pump it is recommended that it be equipped with 6" (hard) suction hose and inlets. Even if a 6-inch suction hose is not available, 6" x 5" and 5" x 4-1/2" reducers may be added on to the inlets, with 4-1/2 inch blind caps. By doing this, any diameter of suction (fitting) can be connected to the dry hydrant at any time, and the adapters are located where they will be needed. Also, suction losses can be significantly reduced when using dual lines.

By adhering to the following guidelines, there will be a minimum of 2 psi atmospheric at the pumps. The total suction lift (pumping head) shall not exceed 20 feet when line, elbow, fitting losses, and elevation head are added. Pumping head shall be figured for each site to include head loss from screen, elbows, line friction, elevation (static head) and hard rubber suction hose to the fire truck. The head loss for the pipe and fittings shall be determined using values from Table 3 multiplied by the equivalent pipe length for pipe and fittings. Equivalent pipe lengths for fittings (intake screen if applicable, elbows, and hydrant connection) are computed by obtaining equivalent pipe length from Table 2 and adding to total length of pipe required. Head loss for the hard suction hose is obtained from Table 4. The total suction lift is:

Total Suction Lift = Head loss for pipe and fittings + Hard suction hose loss + Static lift

Table 2 Equivalent Pipe Lengths for Various Fittings (250 to 1250 GPM Pumping Rate)

Pipe Fitting	**Pipe Diameter in Inches**			
	6	8	10	12
Intake Screen	5	7	8	9
90 degree Elbow (Standard)	16	22	27	32
90 degree Elbow (Long Sweep)	11	14	18	20
45 degree Elbow	7.5	10	13	15
Hydrant Connection (6” x 4-1/2”)	2.5	2.5	2.5	2.5

Table 3 Head Loss in Feet per 100 Feet of Pipe Length (PVC, PIP, SDR-26)

Pumping Rate, GPM	**Pipe Diameter, Inches**			
	6	**8**	**10**	**12**
250	0.58	0.15	0.05	0.02
500	2.08	0.52	0.17	0.07
750	4.42	1.11	0.37	0.15
1000	7.54	1.88	0.64	0.26
1250	11.4	2.85	0.97	0.39

Table 4 - Head Loss in Feet per 100 Feet of Hard Rubber Suction Hose

	Inside Diameter of Hose in Inches				
GPM	**2.5**	**4.0**	**4.5**	**5.0**	**6.0**
250	38.2	3.9	2.2	1.3	0.5
500	138.0	14.0	7.9	4.7	1.9
750		29.8	16.8	10.0	4.2
1000		50.6	28.5	17.1	7.0
1250		76.7	43.2	25.9	10.7

Underwater Water Support

A pipe support shall be provided for the intake screen to assure that it has 2.0 feet of clearance from the pond bottom. The intake shall be firmly held in place where persons boating or fishing may inadvertently disturb it. Anchorage may be at either end by pipe with strap or clamp or other adequate means as approved by the local fire department.

Dry Hydrant

If a dry hydrant is properly installed, inspected, and maintained, it should provide trouble-free service for life. Care should be taken in the planning and design phase of the installation to insure that the maximum benefit is derived from the hydrant installation in the years to come. Rural fire departments should anticipate their future needs 5 to 10 years from now. Providing the best possible delivery rate usually only requires increasing the diameter of pipe being used. The costs associated with increasing the diameter of pipe and fittings are a small percentage of the total cost of the installation.

Also, the following recommendations should be considered by those installing dry hydrants:

- Dry hydrants should be manufactured by a company with adequate financial resources to assure long-term supply.
- Dry hydrant manufacturer should be able and ready to support product in the field with on-site personnel
- Dry hydrant manufacturer should maintain a reasonable on-hand supply of all component parts.
- Dry hydrants made of PVC material must be painted with a high grade epoxy paint where components are exposed to ultraviolet light rays. If the local fire department wishes, they may follow the color code for flowage as follows:

  Red < 500 gpm
  Yellow 500 – 999 gpm
  Green >1000 gpm

Access Road

Access roads shall be installed in accordance with Oklahoma Conservation Practice Standard 560 - Access Road. In addition, the following guidance for access road design and installation is from National Fire Protection Association 1142 Standard:

Table A.9.4.6 Recommendations for Roads to Water Supplies

Width:	Roadbed - 12 ft (3.7 m) Tread - 8 ft (2.4 m) Shoulders - 2 ft (0.6 m)
Alignment:	Radium center line curvature - 50 ft. (15.2 m)
Gradient:	Maximum sustained grade - 8 percent
Side Slopes:	All cut and fill slopes to be stable for the soil involved
Drainage:	Bridges, culverts, or grade dips at all drainage way crossings. Roadside ditches deep enough to provide drainage. Special drainage facilities (tile, etc.) at all seep areas and high-water table areas.
Surface:	Treatment as required for year-round travel.
Erosion Control:	Measures as needed to protect road ditches, cross drains, and cut and fill slopes.
Turnaround:	Turnaround should be designed to handle the equipment of the responding fire department with a minimum diameter of 90 ft
Load Carrying Capacity:	Adequate to carry maximum vehicle load expected.
Condition:	Suitable for all weather use.

References

USDA, NRCS. 2012. Field Office Technical Guide, Section IV, Oklahoma Conservation Practice Standard 432 – Dry Hydrant.

National Fire Protection Association. 2012. NFPA1142: Standard on Water Supplies for Suburban and Rural Fire Fighting

Additional guidance and materials may be found at the National Fire Protection Association website located at: http://www.nfpa.org/

APPENDIX 1 – Example design using Method 1:

Dry Hydrant Design for Central Oklahoma County
Minimum Surface Area = 1.0 Acre (Figure1)
Minimum Depth = 8.2 feet (Figure 2)
Minimum Drainage area = 20 Acres (Figure 3)

Given:

Actual Surface Area = 5.5 Acres.
Pond depth = 14.0 feet total.
Drainage area = 160 acres.
"U" shaped valley.
Local fire department truck pumps 1000 gpm, will use 10 feet of 6- inch diameter hard rubber suction hose.
Pump inlet @ 26 inches above ground line at hydrant (Elev. 102.17)
Ground line @ hydrant = Elev. 100.0
Auxiliary Spillway level = Elev. 97.0
Permanent pool level @ Elev. 95.0
Lateral run pipe length = 40 feet
Riser height = 13 feet.
Minimum Screen length from Table 1 = 3.4 feet
Will use 2 – 90 degree standard elbows and 6 inch x 6 inch hydrant connection

Determine: Diameter of pipe to use and total suction lift (20 foot maximum).

Procedure: Estimate 6-inch I.D. PVC Schedule-40 pipe.

Equivalent pipe length from Table 2 for fitting and screen:

Intake screen	=	5.0 ft
90 degree elbow (std) 16 feet x 2 ea.	=	32.0 ft.
Hydrant connection 6 inches x 6 inches	=	2.5 ft
Total equivalent pipe length for fittings	=	39.5 ft.

Minimum Riser Length = Minimum Required Depth (Figure 2) plus the elevation difference between the pump elevation and normal pool elevation minus 2.0 ft sediment requirement minus the intake pipe diameter.

8.2 ft + (102.2 – 95.0) – 2.0 ft – 6 in. = 12.9 ft

Pipe length = horizontal pipe + vertical pipe = 40 + 12.9 = 52.9 ft.

From Table 3 - Head Loss in Feet per 100 Feet of Pipe Length

- Flow rate = 1,000 gpm
- Pipe size = 6 in Diameter PVC pipe
- Head loss = 7.54 ft per 100 ft

Head loss for pipe and fittings = (52.9 ft. + 39.5 ft) x 7.54 ft./100 ft. = **7.0 ft**

From Table 4 - Head Loss in Feet per 100 Feet of Hard Rubber Suction Hose

- Flow rate = 1,000 gpm
- Hard suction hose (6 in diameter)
- Head loss = 7.00 ft per 100 ft

Hard suction hose loss = 10 ft. x 7.0 ft./100 ft = **0.7 ft**

Design Static lift = 8.2 ft minimum water depth + 2.0 ft flood storage + 26 in to centerline of fire truck pump from ground level + 3 ft above auxiliary spillway elevation minus (2.0 ft below inlet for sediment + 6 in pipe diameter + 2 ft for anti-vortex if required) = 8.2 + 2 + 2.17 + 3.0 – 4.5 = **10.9 feet**.

Maximum allowable static lift = Maximum 15 ft. measured from the centerline of intake up to the top of the hydrant or centerline of pump whichever is higher = Elevation top of hydrant – Centerline of Intake Pipe.

Check elevations: (100.0 + 2.2) minus (86.8 + 2.0 ft + 3 in) = 13.2 feet < 15 feet. OK)

Total suction lift = **7.0** pipe and fitting loss + **0.7** ft. hard suction hose loss + **10.9** ft. static lift = **18.6 feet total suction lift**. (18.7 ft. is less than allowable; therefore 6-inch is OK).

Determine: Volume of available water in gallons between normal pool and the lower limit of the fire protection pool (2 feet above pipe intake if used for anti-vortex control).

Given: Surface area (A_{NP}) = 5.5 acres, Pond Depth (D) = 14.0 feet
Calculate depth from normal pool to bottom of fire protection pool (d)

Normal pool elevation = 95.0
Intake pipe elevation = 102.2 – 12.9 – 0.5 = 88.8
Bottom of fire protection pool = 88.8 + 0.5 + 2.0 = 91.3

d = 95 – 91.3 = 3.7 ft

d = 8.2 ft Minimum depth – 2.0 ft sediment requirement – 0.5 ft intake pipe diameter – 2.0 ft anti-vortex allowance = 3.7 ft.

Percent Maximum Depth = 100 – (d/D x 100) = 100 - ((3.7/14) x 100) = 100 - (0.264 x 100) = 73.6 percent (%)

Percent of Maximum Surface Area = 81.0% (0.81) (From Figure 6).

Available Water (volume) = (d) (A_{NP} + (A_{NP} times Percent of Maximum Surface Area)/2)

Available Water (volume) = (3.7) ((5.5 + (5.5 x 0.81))/2) = 18.4 acre feet

Covert to gallons = 18.4 (43560) (7.48) = 5,995,250 gallons

APPENDIX 2 – Figures used to determine adequacy of the water supply from impoundments

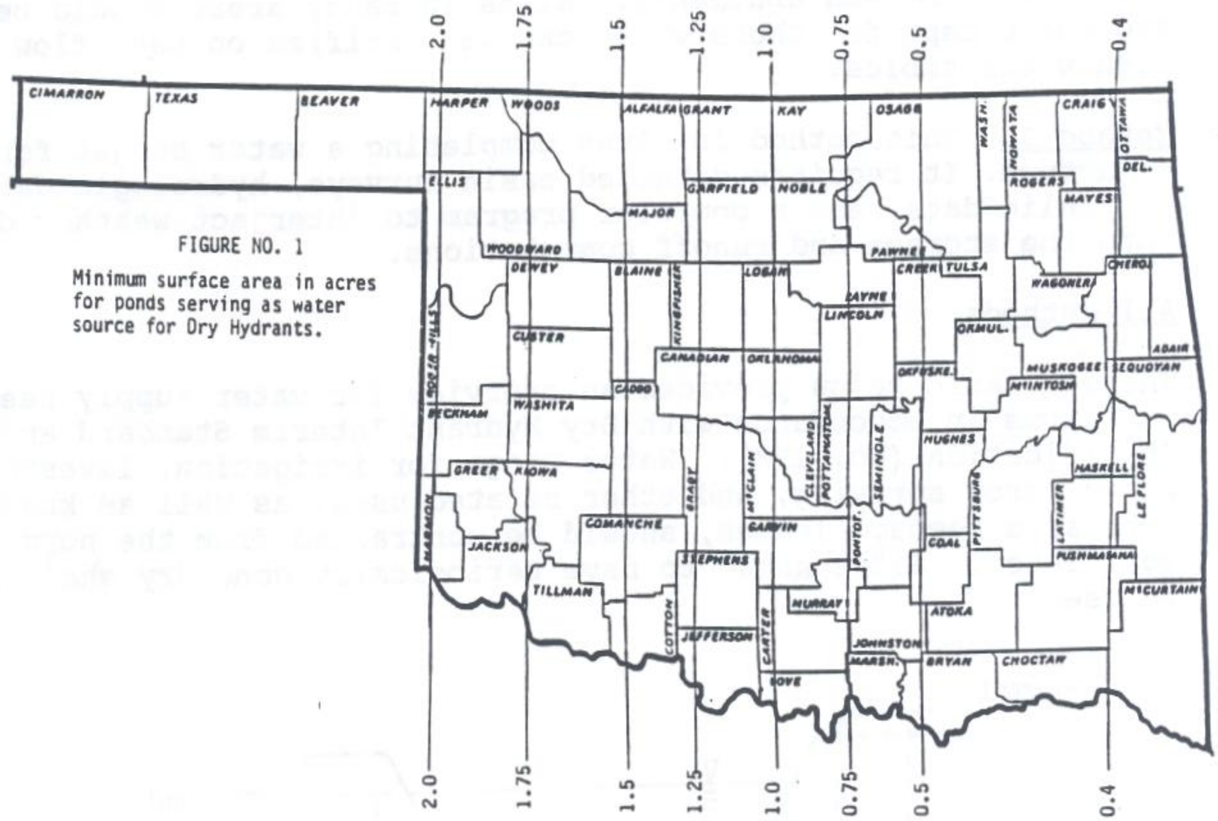


FIGURE NO. 1

Minimum surface area in acres for ponds serving as water source for Dry Hydrants.

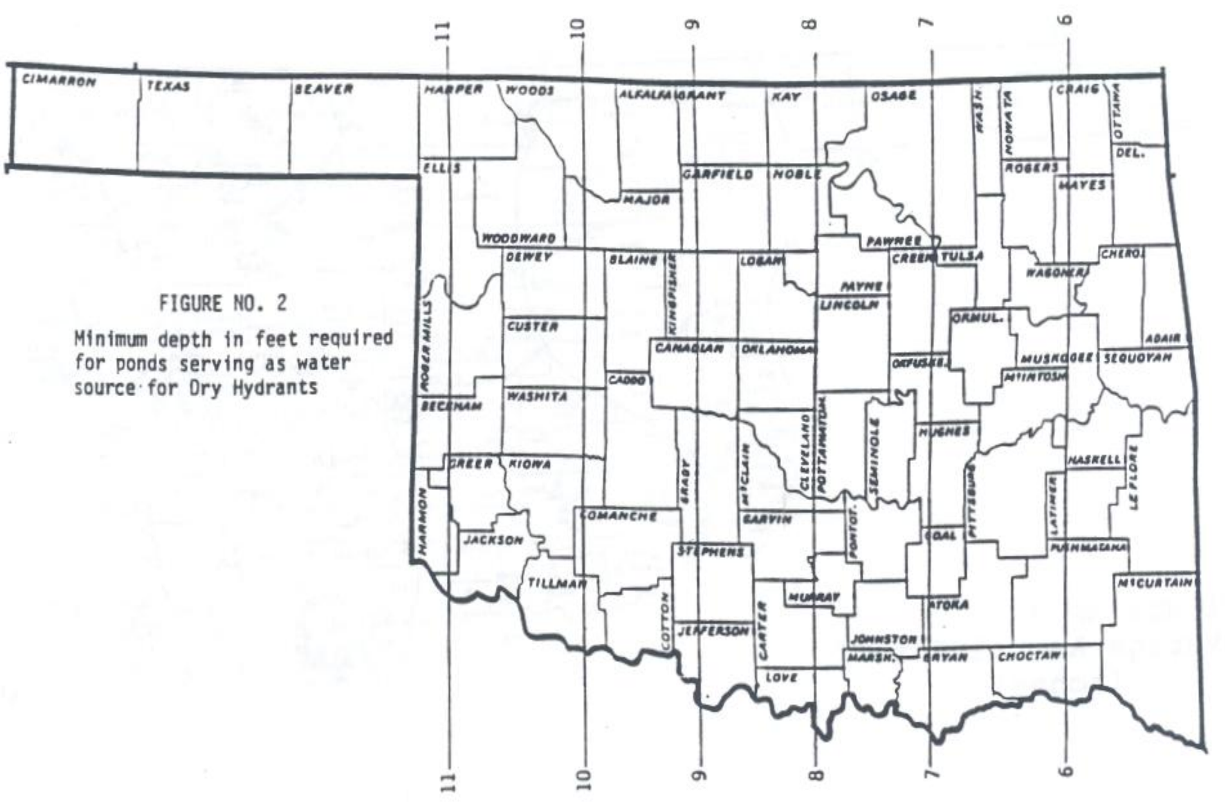


FIGURE NO. 2

Minimum depth in feet required for ponds serving as water source for Dry Hydrants

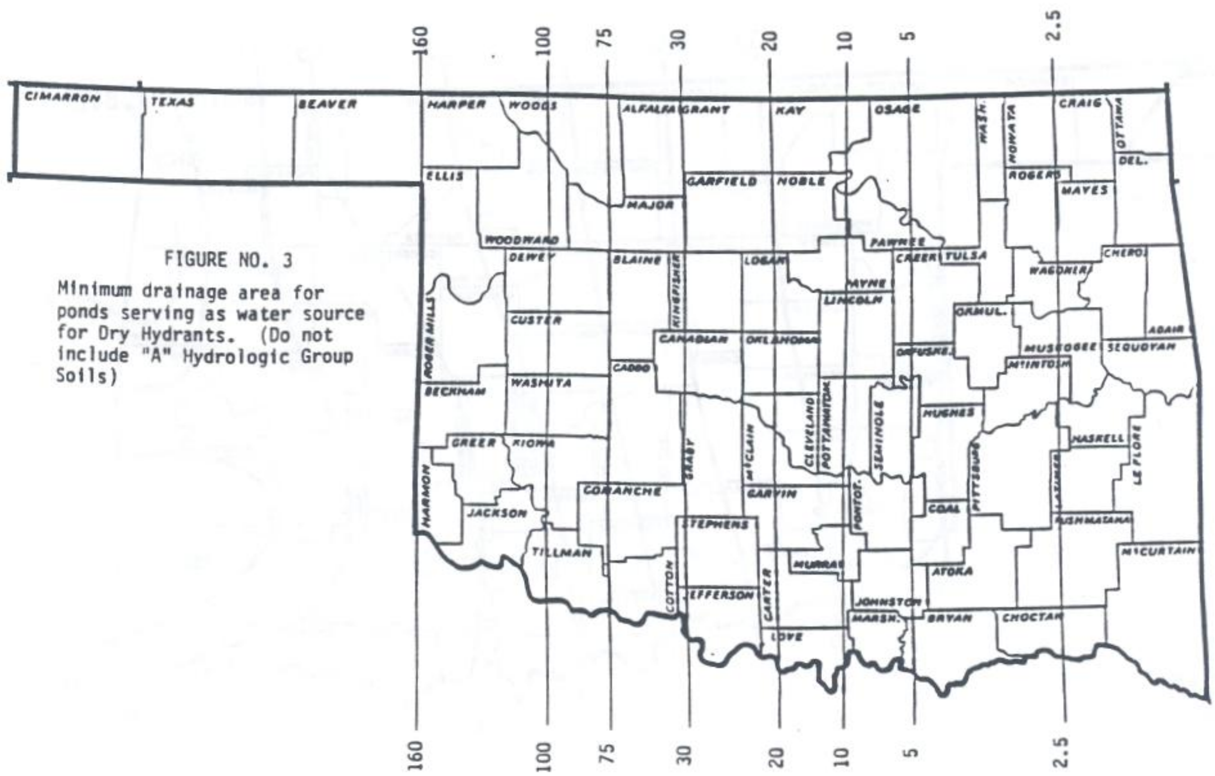


FIGURE NO. 3

Minimum drainage area for ponds serving as water source for Dry Hydrants. (Do not include "A" Hydrologic Group Soils)

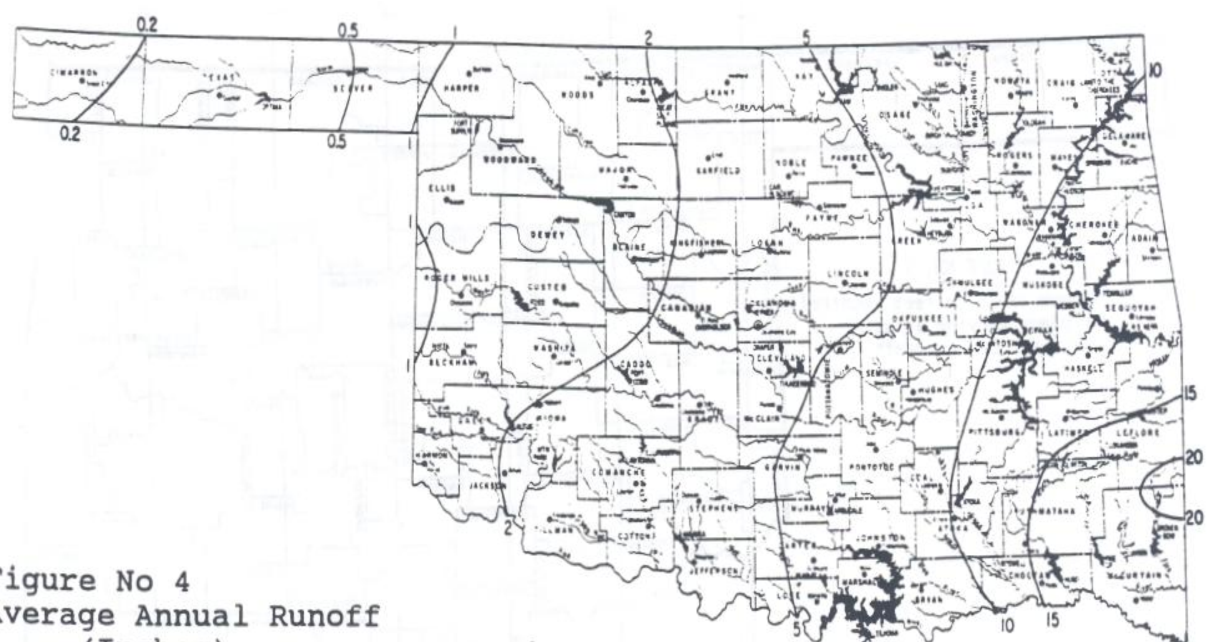


Figure No 4
Average Annual Runoff
(Inches)

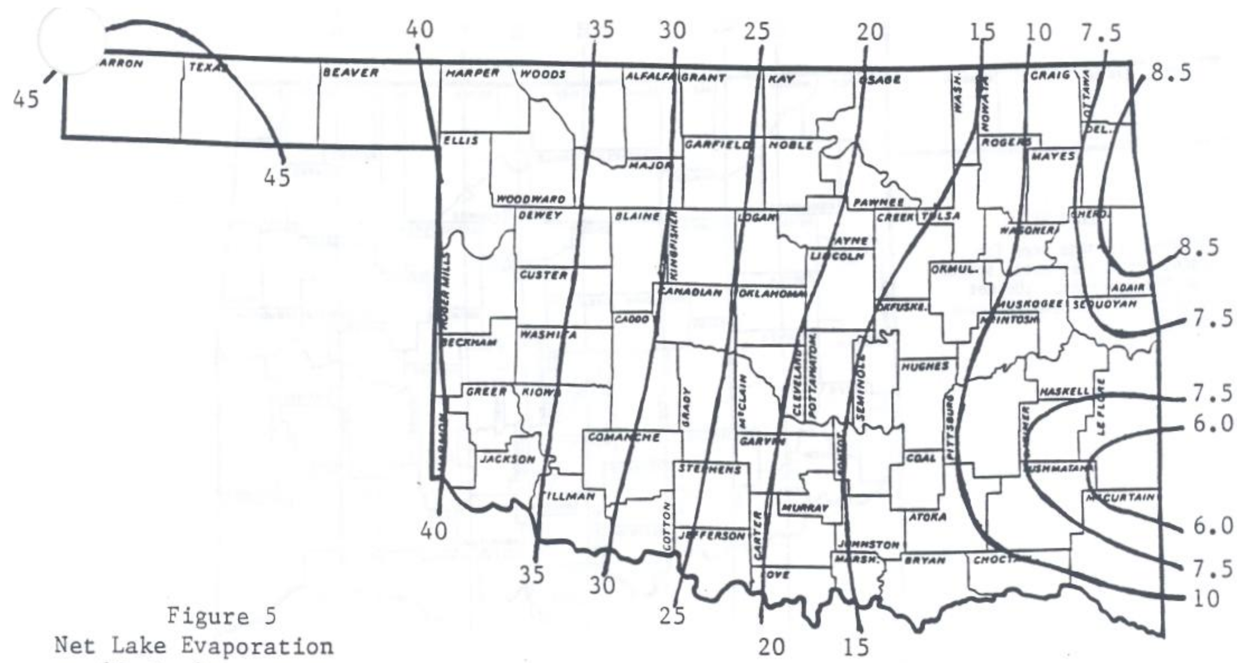


Figure 5
Net Lake Evaporation
(Inches)

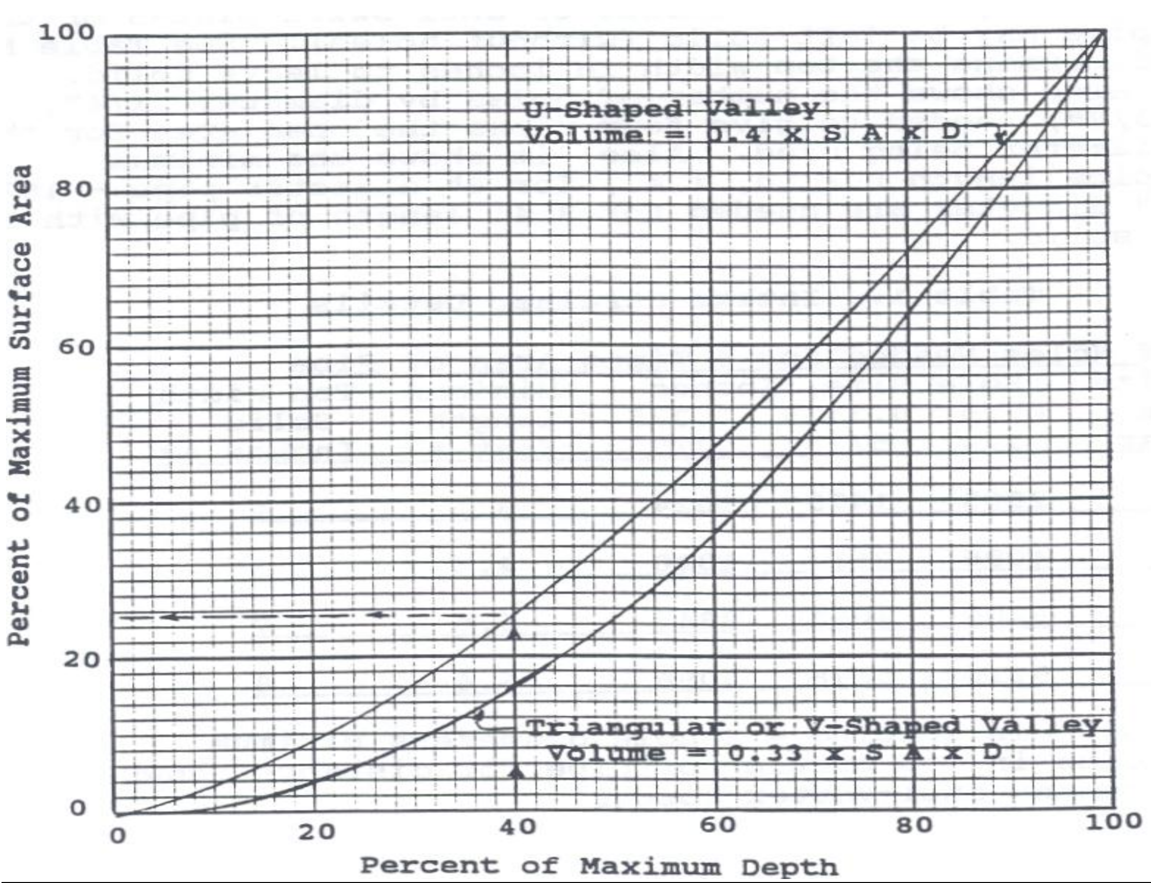


Figure No 6 - Percent Maximum Surface Area Vs. Percent Maximum Depth