NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD
ARIZONA

IRRIGATION RESERVOIR

(No. and Ac.-Ft.)

CODE 436

DEFINITION

An irrigation water storage structure made by constructing a dam, embankment, pit, or tank.

PURPOSE

This practice may be applied as part of a resource conservation system to achieve one or more of the following:

- Store water to provide a reliable irrigation water supply or regulate available irrigation flows.
- Improve water use efficiency on irrigated land.
- Provide storage for tailwater recovery and reuse.
- Provide irrigation runoff retention time to increase breakdown of chemical contaminants.
- Reduce energy consumption.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to irrigation water storage structures that meet one or more of the following criteria:

- The existing available water supply *or irrigation stream* is insufficient to meet irrigation requirements during all or part of the irrigation season.
- Water is available for storage from surface runoff, stream flow, irrigation canals, or a subsurface source.
- *Topographic, geologic, and soil conditions confirm that* a suitable site is available for construction of a storage reservoir.
- *If surface runoff enters the reservoir, the contributing drainage area is or can be protected against erosion so that normal sedimentation does not materially shorten planned reservoir life.*

This practice applies to *the* planning and functional design of storage capacity, and inflow/outflow capacity requirements for irrigation storage reservoirs. Storage reservoirs shall be planned and located to serve as an integral part of an irrigation system.

This practice applies to reservoirs created by embankment structures or excavated pits to store diverted surface water, groundwater, or irrigation system tailwater for later use, or reuse.

The practice also applies to reservoirs created by embankment *or impoundment* structures or excavated pits and tanks constructed of concrete, steel, or other suitable materials used to collect and regulate available irrigation water supplies to accomplish the intended purpose.

CRITERIA

Conservation practices shall be designed on an individual basis to meet site conditions and functional requirements. They shall be part of an approved and overall engineering plan for irrigation, drainage, wildlife, recreation, channel improvement, or similar purposes.

Design and implementation of subsidiary components and/or structures shall meet all applicable Natural Resource Conservation Service (NRCS) conservation practice standards. The criteria for the design of any components not specifically addressed in NRCS practice standards or specifications shall be consistent with sound engineering principles and/or manufacturer recommendations.

Laws and Regulations*. The installation and operation of an Irrigation Reservoir shall comply with all federal, state, Tribal and local*

laws, rules, regulations. Laws and regulations of particular concern include those involving water rights, land use, pollution control, property easements, wetlands, preservation of cultural resources, and endangered species.

The owner is responsible for securing necessary permits and water rights, complying with all laws and regulations, and meeting legal requirements applicable to the installation, operation, and maintenance of the pond and associated structures.

***Cultural Resources and Wildlife**. Impact to cultural resources, wetlands and Federal and state protected species shall be evaluated and avoided or minimized to the extent practicable during planning, design and implementation of this conservation practice in accordance with established National policy, General Manual (GM) Title 420-Part 401; Title 450-Part 401, Title 190-Parts 410.22 and 410.26, National Planning Procedures Handbook (NPPH), National Cultural Resources Procedures Handbook (NCRPH), National Food Security Act Manual (NFSAM), and the National Environmental Compliance Handbook (NECH).*

General Criteria Applicable to All Purposes
Structure type selection (excavated pit, embankment, or tank) shall be based on a site specific assessment involving hydrologic studies, engineering and geologic investigations, available construction materials, and natural storage.

All areas where vegetation has been disturbed during construction shall be seeded following completion of construction. The seeding practices shall meet requirements of the Conservation Practice Standard 342, Critical Area Planting. Seeded areas shall be fenced where necessary to provide protection for the vegetation and control of grazing.

Storage Capacity. Design capacity computations shall be based on planned inflow volumes and rates over the storage period, and outflow volumes and rates required to meet planned irrigation system needs (*based on the irrigation requirements of the crops to be irrigated, the effective rainfall expected during the growing season, the application efficiency of the irrigation method used).*

Structure storage capacity must provide sufficient volume to meet variations in water demand within the irrigation period.

Compute demand flow rates based on the consumptive use-time relationship using anticipated irrigation efficiencies, conveyance losses, and other uses such as leaching, frost control, seepage, and evaporation.

Irrigation storage reservoirs planned primarily to regulate irrigation flows shall have adequate capacity to provide design irrigation application flow rates.

Structure capacity shall provide adequate storage for inflow while maintaining sufficient water levels to insure proper operation of outlet works and provide uniform outflow rate during planned irrigation events.

Provide additional capacity as needed for *the estimated volume of* sediment storage *that will b deposited during the life of the structure*.

Foundation, Embankment, and Spillways. Earthen dams, embankments, pits, associated spillways, and appurtenant structures shall be designed *and constructed* to meet criteria in the applicable *Arizona* Conservation Practice Standards, Pond (378), Dam (402) *or TR-60, as appropriate.*

Drop spillways, chute spillways, and box spillways shall be designed according to the principles of the Engineering Field Handbook and the National Engineering Handbook, Section 5-Hydraulics; Section 11-Drop Spillways; or Section 14-Chute Spillways, as appropriate.

***Foundation cutoff**. A cutoff of relatively impervious material shall be provided under the dam if necessary to reduce seepage through the foundation. The cutoff shall be located at or upstream from the centerline of the dam. It shall*

extend up the abutments as required and be deep enough to extend into a relatively impervious layer or provide for a stable dam when combined with seepage control. The cutoff trench shall have a bottom width adequate to accommodate the equipment used for excavation, backfill, and compaction operations. Side slopes shall not be steeper than one horizontal to one vertical.

Side Slopes*. The combined upstream and downstream side slopes of the settled earth embankments shall not be less than five horizontal to one vertical, and neither slope shall be steeper than two horizontal to one vertical. All slopes must be designed to be stable, even if flatter side slopes are required.*

Seepage. Prevent excessive seepage losses by use of an appropriate method of sealing or lining. *Seepage from irrigation regulating reservoirs shall be controlled to the extent practical when the facility is expected to receive chemical-laden waters. Control may be in the form of natural soil liners, soil additives, commercial liners, or other approved methods.*

Drainage Diaphragm*. The drainage or filter diaphragm shall function both as a filter for adjacent base soils and a drain for seepage that it intercepts. The drainage diaphragm shall consist of sand meeting the requirements of ASTM C33, for fine aggregate. If unusual soil conditions exist such that this material may not meet the required filter or capacity requirements, a special design analysis (designed according to National Engineering Handbook, Part 628 Dams, Chapter 45, Filter Diaphragms) shall be made.*

The drainage diaphragm shall be a minimum of 2 feet thick and extend vertically upward and horizontally at least three times the outside pipe diameter, and vertically downward at least 18 inches beneath the conduit invert. The drainage diaphragm shall be located immediately downstream of the cutoff trench, but downstream of the centerline of the dam if the cutoff is upstream of the centerline.

The drainage diaphragm shall be outletted at the embankment downstream toe using a drain backfill envelope continuously along the pipe to where it exits the embankment. Drain fill shall be protected from surface erosion.

Inlet protection*. Reservoir embankment or excavated side slopes at inlets shall be protected from erosion by use of pipe inlets or other suitable structures. Inlet structure capacity shall be adequate to accommodate the design inflow rate.*

Overflow Protection. *An* Overflow protection *structure having a capacity equal to or greater than the inlet stream* shall be provided if overflow of the irrigation storage reservoir is possible. *This structure may be designed and installed in combination with the outlet works.*

Inlet and Outlet Works. Design conduit and open spillways according to guidelines in appropriate chapters of the NRCS National Engineering Handbook.

Provide inlet works when needed to prevent erosion or control flows into the irrigation storage reservoir. Inlet works may consist of a direct pumping system, conduit, grassed channel, lined channel, chute, head gates, valves, or other appurtenances necessary to safely convey and control water entering the structure.

Outlet works shall be provided for controlled withdrawal, transfer, or release of irrigation water. Outlet works may consist of a direct pumping system or a conduit from the storage reservoir to an area of use. The capacity of the outlet works shall be adequate to provide the outflow rate needed to meet irrigation system demands.

Design and install specialized inlet or outlet works when needed to avoid entraining or impinging aquatic organisms.

Additional Criteria Applicable to Storage for Tailwater Recovery and Reuse

Irrigation regulating reservoirs used in irrigation tailwater recovery and reuse systems are often referred to as tailwater pits or sumps.

Capacity. *Capacity requirements for irrigation regulating reservoirs for tailwater recovery shall be based on irrigation system runoff volume and rate, as well as, required level of water control at the point tailwater is returned to the irrigation system. Excessive seepage losses shall be prevented by the use of an adapted method of sealing or lining.*

For systems where tailwater is discharged into an irrigation pit or regulating reservoir or into a pipeline having facilities for regulating fluctuating flows (e.g. a float valve), small pits or sumps with frequently cycling pumping plants may be used. For systems unable to regulate flows, tailwater sumps or pits shall be made large enough to provide the regulation needed to permit efficient use of the water.

When energy sources for tailwater pump back systems are subject to interruption, safe emergency bypass areas cannot be provided, or tailwater discharges violate local or state regulations, tailwater storage requirements shall, as a minimum, include a volume adequate to store all tailwater runoff from a single irrigation set.

Inlet protection. *Sumps and pits shall be equipped with inlets designed to protect side slopes and collection facilities from erosion. A dike, ditch, or water control structure shall be provided, if required by state law, to limit the entrance of rainfall runoff into the designed inlet. Sediment traps shall be installed as needed.*

Additional Criteria Applicable to Irrigation Runoff Retention Time to Increase Breakdown of Chemical Contaminants

Capacity. Where additional storage or flow regulation are required to provide adequate retention time for breakdown of chemicals in runoff waters, storage facilities shall be sized accordingly. Allowable retention times shall be site specific to the particular chemical of concern.

Additional Criteria Applicable to All Purposes

Earth embankment structures are potentially hazardous and precautions must be taken to prevent serious injury or loss of life. Protective guardrails, warning signs, fences, or lifesaving equipment shall be added as needed.

If the area is used for livestock, the structures, earth fill, vegetated spillways, and other areas should be fenced as necessary to protect the structure. Near urban areas, fencing may be necessary to control access and exclude traffic that may damage the structure or to prevent serious injury or death to trespassers. Fencing shall comply with the guidelines in conservation practice standard 382, Fencing.

Investigations, Surveys and Design Criteria. *Documentation requirements will be as outlined below, in additional to the documentation requirements of the practice components used in the system.*

Make a preliminary site assessment or reconnaissance to determine site suitability, topography, watershed, soil limitations, and may include:

1. *Pits, trenches, borings, review of existing data or other suitable means of soil investigation shall be conducted to characterize materials within the excavation, determination of foundation materials/conditions, and location of borrow material(s). Soil materials shall be classified using the Unified Soil Classification System.*
2. *The area to be excavated for the reservoir shall be investigated, thoroughly and to the depth of at least 2 feet below the anticipated lowest expected grade, to determine the seepage potential through the pond and the difficulty of excavation.*
3. *Where irrigation is the primary purpose of the impoundment, determine that irrigation storage is adequate and feasible, including water supply considerations.*
4. *Drainage area, for structures supplied by surface runoff.*
5. *Verify appropriate state laws for permitting and notify landowner of his/her responsibilities.*
6. *Verification or certification of used materials (if any).*

To adequately plan and layout this practice, a detailed topographic survey is required, that adequately details:

1. *Site topography, as needed to show the physical features of the site, including existing features/practices, field elevations, location of any utilities or markers, etc.*
2. *Embankment Ponds: Survey the embankment centerline profile, extending above the expected elevation of the dam and beyond the location of the auxiliary spillway. Centerline profile rod readings shall be taken at all breaks in grade and at intervals no greater than 50 feet. Survey a significant number of cross sections to accurately compute earthwork quantities.*
3. *Excavated Ponds or dugouts: record an adequate number of reading around the perimeter, to accurately compute earthwork quantities*
4. *Profile and cross sections at maximum fill section and along the centerline of the principal and auxiliary spillway, including the inlet, level and outlet sections, and far enough downstream to determine tail water conditions.*
5. *A permanent benchmark(s) shall be set and described. Preferably, the elevations and coordinates should be based on a local (assumed) or coordinate system (State or grid) and clearly stated on the plan. Datum may be in the form of Northing and Easting coordinates, or Longitude and Latitude.*
6. *Set reference stakes, as needed*

Where applicable, USGS 7.5-minute topographic Quadrangles may be used, provided hydraulic analysis verifies minimum criteria are meet at all locations.

The design of a practice is the application of Field Office Technical Guide practice standards, and using experience and judgment in the development of a solution to the problem or the objective. All computations and decisions made during the design of a practice are to be checked by another qualified individual and appropriate notations made. Design computations, calculations or analysis shall meet the following criteria:

1. *Compute the hydrologic requirements (peak flow, storm runoff, annual yield, discharge, frequency, etc.) per EFM2, TR-55, SITES98 or other approved method for the contributing watershed, where applicable.*
2. *Hydraulic data for principal and auxiliary spillways, drawdown pipe, and outlet channel, etc.*
3. *Determine and document hazard classification of the reservoir, including rationale for assessment.*
4. *Complete soils or geological investigations or reports and prepare applicable construction and material specifications*
5. *Structural design computations, as needed, and determine pond dimensions (height, side slopes, top width, etc.)*
6. *Surface area, storage, sediment capacity, and stage-storage.*
7. *Calculate or determine volume computations, including earthwork estimates, materials, etc.*
8. *Subsidiary and applicable components shall be designed in accordance with applicable conservation practice standards (i.e., structures shall meet the requirements of Conservation Practice 587, Structure for Water Control, etc.).*

***Installation and Basis of Acceptance**. For construction that does not meet State, OSHA, or Tribal criteria or requirements where deficient construction materials were used, NRCS may consider a waiver request for approval of construction after it has received a signed and sealed construction and/or material exemption from a licensed engineer. Required exemption shall be for installation of materials that do not meet minimum quality criteria as found in applicable Standards, Specifications, ASTM's, AWWA standards, etc.*

Contractors performing work under this practice shall abide by all Federal, State or Tribal laws or criteria, and must be licensed by the state DWR or board of technical registers where the work is being implemented.

CONSIDERATIONS

In highly visible public areas and those associated with recreation, careful considerations should be given to landscape resources. Landforms, structural materials, water elements, and plant materials should visually and functionally complement their surroundings. Exposed concrete surfaces may be formed to add texture or finished to reduce reflection and to alter color contrast. Site selection can be used to reduce adverse impacts or create desirable focal points.

Special consideration should be given to maintaining or improving habitat for fish and wildlife where applicable

The exposed surfaces of the embankment, earth spillway, outlet channel, borrow area, spoil, and other areas disturbed during construction shall be seeded. Seedbed preparation, seeding, fertilizing, and mulching shall comply with Conservation Practice Standard 342, Critical Area Planting.

Where conditions preclude or make it difficult to establish vegetative cover, consider using non-vegetative coverings such as rock, geoweb, gabions, interlocking blocks or other type of protection.

Clay or plastic pond liners should be used on excavated ponds where seepage losses are considered excessive.

When planning this practice, the following items should be considered where applicable:

- Potential energy savings resulting from regulation of irrigation flows, tailwater reuse, improved pumping plant efficiency, or management changes.
- Planting of critical areas at the completion of construction to protect the structure and borrow areas, and prevent erosion.
- Effects of soil physical and chemical properties, as well as potential soil limitations, relating to embankment construction, compaction, stability, bearing strength, pool area seepage, and soil corrosivity. Refer to soil survey data as a preliminary planning tool for assessment of pool and borrow areas, and conduct
- On-site soil investigations during the final planning stage.
- Perimeter fences to prevent human and animal access and emergency escape facilities to minimize human safety hazards.
- Construction-related effects on air quality and on water quality of downstream water courses.
- Potential for earth moving construction to uncover or redistribute toxic materials or on-site invasive species.
- Development of water budgets, to quantify sources of inflow (precipitation and withdrawals), and outflow (evapotranspiration and losses).
- Impacts on downstream flows or aquifers that could affect other water uses or users.
- Impacts on the quantity of downstream flows, which could have undesirable environmental, social, or economic effects.
- Impacts of erosion, sediment, soluble contaminants, seeds or vegetative materials of invasive species, and contaminants attached to sediment in runoff.
- The movement of dissolved substances to ground water.
- Effects of water temperature changes on aquatic and wildlife communities.
- Timing of vegetation-disturbing maintenance activities, to avoid grassland bird nesting seasons.
- Impacts on wetlands or water-related wildlife habitats.
- Impacts on the visual quality of water resources and the landscape.
- Impacts on cultural resources.
- Performing periodic water quality analysis to evaluate salinity, nutrients, pesticides, and pathogens.
- Opportunities to include variety in vegetation for embankment stabilization or revegetation maintenance, that would provide pollinator forage from early spring to late fall.
- *Effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.*

- *Consider the potential for irrigation water management.*
- *Ability of structure to trap sediment and sediment-attached substances carried by runoff.*
- *Short-term and construction-related effects on the quality of downstream water courses.*
- *Potential for earth moving during construction to uncover or redistribute toxic materials.*

Design alternatives presented to the client should address economics, ecological concerns and acceptable level of risk for design criteria as it relates to hazards to life or property.

PLANS AND SPECIFICATIONS

Use Arizona standard drawings to the extent possible. These may be supplemented by additional drawings or specification notes on the drawings to provide full installation instructions.

Construction plans shall include all components needed for the safe operation of the proposed improvements such as railing, fencing, or warning signs as appropriate. The plans shall address operations near existing utilities, trench excavations and any other items related to construction of the structure that may pose a safety risk to those involved.

Development of plans and specifications for constructing irrigation storage reservoirs *will be guided by the National Engineering Handbook, Part 650, the Engineering Field Handbook, Chapter 5, and shall be in accordance with the National Engineering Manual, Parts 541 and 542, and* shall be in keeping with this standard, *prepared for each specific site* and shall *adequately* describe the requirements for applying *or installing* the practice to achieve its intended purpose. *As a minimum, the plans and specifications shall include:*

- *Project location map, including section, township and range, North arrow, cooperator/owner acknowledgement and certification signature blocks, engineering job class (cover sheet);*
- *References that the owner/cooperator are responsible for all permits, rights-of-way, easements and the contact, coordination and location determination of any existing utilities or clearances (buried utility disclaimer);*
- *If applicable, a map showing the location of the practice(s) or system in reference to a known or established benchmark or reference point with the location, description and elevation clearly shown. Topographical features and/or controls shall be shown, showing tie in with existing or other planned practices;*
- *Field surveys and notes, soil investigations or geologic soil boring locations and soil classifications, earthwork or material estimates/quantities (if applicable);*
- *System overview and layout (i.e., alignment, stationing, topographical features, and reference to existing or proposed features or facilities; location and plan view of the pond and reservoir area; location of the principal and auxiliary spillway; details of seepage control; requirements for diverting water or de-watering the site, size and type of conduits and appurtenances, soil or waste disposal, location and extent of borrow source, vegetative requirements, construction/installation criteria, State and Federal [OSHA] safety requirements, etc.);*
- *Profile typical cross section of the excavations, embankments, spillways, and/or cutoff trench along proposed centerline with stationing, side slopes, dimensions (bottom width, embankment height) and elevations; details for pipe conduits, including invert elevations, size, type of material, seepage control, pipe cradle, and joints; foundation or subgrade preparation and requirements; and earthfill compaction methods;*
- *Sufficient sectional, dimension or detail views of all system components and appurtenances (i.e., details for pipe conduit size and material, drainage or filter diaphragm, pipe cradle, special joints) as required, for proper system functionality, including concrete reinforcement details or steel schedules, as appropriate.*
- *Use Arizona Construction and Material Specifications for each item of work and material, as applicable and available. Additional specifications may need to be written to provide full material and installation instructions. Fill in blanks and add or delete*

items from the specifications to make them fit the job as needed.

Plans and specifications for constructing earthen irrigation storage reservoirs shall be based on criteria found in NRCS Conservation Practice Standards, Pond (378), or Dam (402).

Plans and specifications for tanks constructed of non earthen materials shall be based on construction and materials specifications for NRCS Conservation Practice Standard, Watering Facility (614).

All designs completed by non-NRCS personal shall meet minimum State licensing board requirements and NRCS requirements and criteria as outlined in the General Manual, the National Engineering Manual (including Arizona Supplements), and the National Engineering Handbook.

ONCE ALL PARTIES HAVE ACCEPTED AND SIGNED THE PLANS AND SPECIFICATIONS, NO CHANGES SHALL BE MADE TO THE DRAWINGS OR SPECIFICATIONS WITHOUT PRIOR APPROVAL OF NRCS.

OPERATION AND MAINTENANCE

An operation and maintenance *(O&M)* plan *specific to each site and facilities* shall be prepared for *and reviewed with the* landowner, *cooperator* or operator *responsible for the operation and maintenance and shall be commensurate with the size and complexity of the project.* The plan *shall document needed actions, including reference to periodic inspections and the prompt repair or replacement of damaged components, and shall* provide specific instructions for operating and maintaining facilities to ensure they function properly *and adequately throughout their expected life.*

The plan shall include the following provisions, *as a minimum*:

- Periodic cleaning and re-grading of water storage facilities to maintain functionality.
- *The reservoir should be inspected periodically and especially after heavy rains to determine whether it is functioning properly or if repairs are needed.*
- Periodic inspection, removal of debris, *trash, foreign materials or blockage,* and repair if needed of trash racks and inlet and outlet structures to assure proper operation.
- Routine maintenance of mechanical components in accordance with manufacturer recommendations.
- Periodic inspection and maintenance of embankments and earth spillways to repair damage or control erosion and undesirable vegetation.
- *The vegetative cover on the dam and earth spillway shall be maintained by mowing, fertilizing or burning when needed. Trees can cause leaks and safety hazards and should not be permitted on the embankment or in the auxiliary spillway.*
- Periodic removal of sediment from traps or storage facilities to maintain design capacity and efficiency.
- Periodic Inspection or testing of all pipelines and pumping plant components and appurtenances, as applicable.
- *If seepage through or under the dam occurs, proper corrective measures shall be taken immediately.*
- *Eradicate or otherwise remove all rodents or burrowing animals that have or may potentially damage any part of the delivery or application facilities. Immediately repair any damage caused by their activity.*
- *Immediately repair any damage resulting from vandalism, vehicles, or livestock.*
- *Inspect for safety of people or animals using the area near the structure.*
- *Periodic water quality analysis as necessary to evaluate nutrients, pesticides, and pathogens.*

REFERENCES

- *USDA-NRCS, National Engineering Manual (NEM), 2nd Edition*
- *National Engineering Handbook, Part 628, Dams, Chapter 50 – Earth Spillway Designs, Part 624 Drainage Water Table Control, Part 630 Hydrologic Engineering, Part 634 Hydraulic Engineering, Part 636 Structural*

Design and Drop Spillways, Part 639 Erosion Control Engineering

- *National Engineering Handbook, Part 650, Engineering Field Handbook, Chapter 1 – Engineering Surveys; Chapter 2 – Hydrology, including the Emergency and Principal Spillway Proportioning Guide, Chapter 3 – Hydraulics, Chapter 4 – Elementary Soils Engineering, Chapter 5 – Preparation of Engineering Plans, Chapter 6 – Structures, Chapter 7 – Grassed Waterways & Outlets, Chapter 11 – Ponds and Reservoirs, Chapter 13 – Wetland Restoration, and Chapter 17 – Construction & Construction Materials*
- *USDA-NRCS, TR-62 Engineering Layout, Notes, Staking and Calculations; TR-56, Wave Protection For Earth Dam Embankment; TR-60, Earth Dams and Reservoirs; TR 67, Reinforced Concrete Strength Design; TR-69, Riprap For Slope Protection Against Wave Action; TR-77, Design & Installation of Flexible Conduits*
- *NRCS Field Office Technical Guide (eFOTG), Section IV, Conservation Practice Standard – Irrigation Pipeline, 430*
- *AASHTO M252, M294*
- *ARS-NC-33, Hydraulics of Closed Conduit Spillways, Part XIV*
- *ASTM D1248, D3350 Chapter 40-4 F.A.C, Chapters 487.064 F.A.C. (pesticides) and 567.087 F.A.C. (fertilizers)*
- *NRCS Conservation Practice Standards Critical Area Planting, Code 342*
- *General Manual, Title 420-Part 401, Title 450-Part 401, Title 190-Parts 410.22 and 410.26*
- *National Environmental Compliance Handbook*
- *National Planning Procedures Handbook*
- *USDA NRCS, Engineering Design Standards – Far West States*
- *National Cultural Resources Handbook*
- *Agricultural Handbook No. 590, Ponds – Planning, Design and Construction*