Natural Resources Conservation Service
CONSERVATION PRACTICE STANDARD

SATURATED BUFFER

CODE 604
(ft)

Current	Proposed
DEFINITION A subsurface, perforated distribution pipe used to distribute drainage system discharge beneath a vegetated buffer along its length and discharge channel.	**DEFINITION** A subsurface, perforated distribution pipe used to reduce the concentration of nitrate in agricultural drainage water diverted beneath a vegetated buffer along its length and discharge channel.
PURPOSE Install the practice to achieve one or more of the following purposes: • Reduce nitrate loading from subsurface drain outlets through vegetation uptake and denitrification • Enhance or restore saturated soil conditions in riverine, lacustrine fringe, slope, or depression wetland hydrogeomorphic classes	**PURPOSE** Install the practice to achieve one or more of the following purposes: • Reduce nitrate loading from subsurface drain outlets through vegetation uptake and denitrification • Enhance or restore saturated soil conditions in riverine, lacustrine fringe, slope, or depression wetland hydrogeomorphic classes
CONDITIONS WHERE PRACTICE APPLIES This practice is applicable to lands with a subsurface drainage system adaptable to discharge in a vegetated area. Apply this practice where the soils and topography of the vegetated discharge area can maintain a raised water table without adverse effects to crops, channel banks, shorelines, or adjacent land. This practice does not apply to underground outlet systems. This practice applies to subsurface drainage systems. If the system includes surface inlets, this practice applies only if the inlets are	**CONDITIONS WHERE PRACTICE APPLIES** This practice is applicable to lands with a subsurface drainage system adaptable to discharge in a vegetated area. Apply this practice where the soils and topography of the vegetated discharge area can maintain a raised water table without adverse effects to crops, channel banks, shorelines, or adjacent land. This practice does not apply to underground outlet systems. This practice applies to subsurface drainage systems. If the system includes surface inlets, this practice applies only if the inlets are

adequately protected to prevent entry of soil and debris capable of plugging the distribution pipes. Do not use this practice to discharge septic system effluent or animal waste.	adequately protected to prevent entry of soil and debris capable of plugging the distribution pipes. Do not use this practice to discharge septic system effluent or animal waste.
CRITERIA **General Criteria Applicable to All Purposes** Conduct geologic and soil investigations to confirm— • Conditions, such as a restrictive layer, are present to create saturated conditions when water is diverted from a subsurface drainage system. • The absence of pockets or layers of high hydraulic conductivity soil that could provide preferential flow paths. • A minimum of 0.75 percent organic carbon (1.2 percent organic matter) in the top 2.5 feet of soil. • The absence of abandoned drain pipes in the buffer area that could continue to drain the buffer. • A minimum width of 30 feet vegetated buffer zone. Locate and design the system to maximize the amount of subsurface drainage water distributed to the potentially saturated soil zone. Ensure there are no hydrologic trespass or other adverse impacts to adjacent lands. Place the distribution pipe, at a minimum, 2 feet below the soil surface. Avoid placing the distribution pipe along any channels incised deeper than 8 feet, unless a slope stability analysis shows an acceptable level of safety against saturated streambank failure. Slope stability analysis may encompass geological investigations and reliance on local knowledge and field observations of bank stability and lateral migration potential. Local knowledge and field observation relies on signs that imply the existing bank does not exhibit an unstable slope and has adequate vegetative cover with a stream channel that does not show recent lateral shifting in the floodplain. The NRCS Stream Visual Assessment Protocol 2	**CRITERIA** **General Criteria Applicable to All Purposes** Conduct geologic and soil investigations to confirm— • Conditions are present to create saturated conditions when water is diverted from a subsurface drainage system. A site conducive to anaerobic conditions in the soil shows evidence of a high water table reaching the carbon-rich soil profile or the presence of a shallow hydraulically restricting layer. • The absence of pockets or layers of high hydraulic conductivity soil that could provide preferential flow paths between the distribution pipe and the receiving channel or water body. • A minimum of 0.75 percent organic carbon (1.2 percent organic matter) in the top 2.5 feet of soil throughout the saturated buffer footprint as indicated in representative soil samples. • The absence of abandoned drain pipes in the buffer area that could continue to drain the buffer. • A minimum width of 30 feet vegetated buffer zone in the absence of a detailed optimum width analysis for maximum nitrate removal. Locate and design the system to maximize the amount of subsurface drainage water distributed to the potentially saturated soil zone. Ensure there is no hydrologic trespass or other adverse impacts to adjacent lands. Place the distribution pipe, at a minimum of 2 feet below the soil surface. Streambank geometry, soil type, and subsoil saturation influence the risk of bank sloughing. Perform a slope stability analysis to show an

(SVAP2) offers a bank condition element with descriptions of visual evidence of bank stability. For sites with obvious and observed bank stability problems, or if the proposed condition is predicted to introduce bank stability problems, refer to NRCS Conservation Practice Standard (CPS) Streambank and Shoreline Protection (Code 580) for protective measures, or alternatively, find a more stable site for the proposed saturated buffer. **Flow** DRAINMOD, other appropriate model simulations, drainage mainline capacity, or drainage system drainage coefficient with area drained can be used to determine drainage system capacity. Provide a positive hydraulic grade for drainage water to exit the saturated buffer distribution line. Minimum saturated buffer design flow is 5 percent of drainage system capacity or as much as practical based on the available length of the vegetated buffer. Use soil profile average saturated hydraulic conductivity, saturated buffer design flow rate, and hydraulic heads available at the site to compute minimum buffer dimensions and length of distribution pipe required to meet selected saturated buffer design flow. **Water control structure** Design a water control structure to maintain the target water table elevations over the distribution pipe during the management period. Use the criteria found in NRCS CPS Structure for Water Control (Code 587). Locate the water control structure where it is accessible for water table observation and for operation and maintenance. The structure location must not cause water to back up into a main or lateral drainage system beyond a property line unless the upstream landowner provides written permission. Convey drainage water exceeding the design capacity of the saturated buffer through an overflow pipe to a suitable stable outlet. Use nonperforated pipe for the overflow pipe for a minimum	acceptable level of safety against saturated streambank failure. Slope stability analysis may encompass geological investigations and reliance on local knowledge and field observations of bank stability and lateral migration potential. Local knowledge and field observation relies on signs that imply the existing bank does not exhibit an unstable slope and has adequate vegetative cover with a stream channel that does not show recent lateral shifting in the floodplain. The NRCS Stream Visual Assessment Protocol 2 (SVAP2) offers a bank condition element with descriptions of visual evidence of bank stability. For sites with obvious and observed bank stability problems, or if the proposed condition is predicted to introduce bank stability problems, refer to NRCS Conservation Practice Standard (CPS) Streambank and Shoreline Protection (Code 580) for protective measures, or alternatively, find a more stable site for the proposed saturated buffer. **Flow** Use DRAINMOD (or other appropriate model simulations) to model drainage mainline capacity, or a drainage system drainage coefficient with area drained to determine drainage system capacity. Provide a positive hydraulic grade for drainage water to exit the saturated buffer distribution line. Minimum saturated buffer design flow is 5 percent of drainage system capacity. Lower design flow is permissible to optimize nitrate load removal. Use soil profile average saturated hydraulic conductivity, saturated buffer design flow rate, and hydraulic heads available at the site to compute minimum buffer dimensions and length of distribution pipe required to meet selected saturated buffer design flow. **Water control structure** Design a water control structure to maintain the target water table elevations over the distribution pipe during the management period. Use the criteria found in NRCS CPS Structure for Water Control (Code 587). Locate the water control structure where it is accessible for water table observation and for operation and maintenance. The structure location must not cause water to back up into a main or lateral drainage system beyond a property line, adversly affect

of 20 feet from the water control structure to avoid draining the saturated soil zone around the water control structure. **Distribution pipe** Design the distribution pipe and overflow pipe according to the criteria found in NRCS CPS Subsurface Drain (Code 606). Ensure the capacity of the distribution pipe is greater than the saturated buffer design flow to ensure that the soil lateral flow capacity rather than the distribution pipe capacity limits saturated buffer flow. Situate the distribution pipes on a topographic contour or grade to facilitate uniform ground water inflow to the saturated zone. Add additional water control structures as needed for flow uniformity. The maximum elevation difference between structures is 3 feet. **Vegetation** Establish permanent vegetation on the soil saturation area and any other disturbed areas to prevent erosion and to utilize nitrogen from the drain water. The soil saturation area to be vegetated must be at least 30 feet wide for the entire length of the distribution pipe. Refer to NRCS CPS Conservation Cover (Code 327), Critical Area Planting (Code 342), or Forage and Biomass Planting (Code 512) for criteria on plant species selection; planting rates, methods, and dates; fertilization; and other factors to ensure a successful planting. Select the appropriate vegetative CPS based on planned activities on the site, which can include secondary benefits such as habitat or hay production as well as soil saturation. Do not allow livestock to utilize the vegetated buffer area.	adjacent properties or water users, unless agreed to by signed written letter, easement, or permit. Convey drainage water exceeding the design capacity of the saturated buffer through an overflow pipe to a suitable stable outlet. Use nonperforated pipe for the overflow pipe for a minimum of 20 feet from the water control structure to avoid draining the saturated soil zone around the water control structure. **Distribution pipe** Design the distribution pipe and overflow pipe according to the criteria found in NRCS CPS Subsurface Drain (Code 606). Ensure the capacity of the distribution pipe is greater than the saturated buffer design flow to ensure that the soil lateral flow capacity rather than the distribution pipe capacity limits saturated buffer flow. Situate the distribution pipes on a topographic contour or grade to facilitate uniform ground water inflow to the saturated zone. Add additional water control structures as needed for flow uniformity. The maximum elevation difference between structures is 3 feet. **Vegetation** Establish permanent vegetation on the soil saturation area and any other disturbed areas to prevent erosion and to utilize nitrogen from the drain water. The soil saturation area to be vegetated must be at least 30 feet wide for the entire length of the distribution pipe. Saturated buffer minimum width may be reduced when a detailed optimum width analysis for maximum nitrate removal is performed. Refer to NRCS CPS Conservation Cover (Code 327), Critical Area Planting (Code 342), or Forage and Biomass Planting (Code 512) for criteria on plant species selection; planting rates, methods, and dates; fertilization; and other factors to ensure a successful planting. Select the appropriate vegetative CPS based on planned activities on the site, which can include secondary benefits such as habitat or hay production as well as soil saturation. Do not allow livestock to utilize the vegetated buffer area.
Additional Criteria to Reduce Nitrate Loading	**Additional Criteria to Reduce Nitrate Loading**

Provide a means to ensure saturated conditions within the high soil organic carbon region of the soil profile when adequate drain flows exist. Design the system to maintain a water table within 12 inches of the soil surface at the location of the distribution pipe near the water control structure during the management period. For sites with adequate soil organic carbon at depths greater than 2.5 feet, the water table setting may be lowered from the 12-inch threshold by the amount of additional depth. Maintain the water control structure at the design level except when the water table must be lowered for providing an adequate root zone for the crop, trafficability for field work, adverse weather conditions, or system maintenance.	Provide a means to ensure saturated conditions within the high soil organic carbon region of the soil profile when adequate drain flows exist. Design the system to maintain a water table within 12 inches of the soil surface at the location of the distribution pipe near the water control structure during the management period. For sites with adequate soil organic carbon at depths greater than 2.5 feet, the water table setting may be lowered from the 12-inch threshold by the amount of additional depth. Maintain the water control structure at the design level except when the water table must be lowered for providing an adequate root zone for the crop, trafficability for field work, adverse weather conditions, or system maintenance.
Additional Criteria to Enhance or Restore Saturated Soil Conditions Design the system to replicate ground water levels shown in the "Water Features" report of the Water Features section of the USDA Web Soil Survey report for the site.	**Additional Criteria to Enhance or Restore Saturated Soil Conditions** Design the system to replicate ground water levels shown in the "Water Features" report of the Water Features section of the USDA Web Soil Survey report for the site.
CONSIDERATIONS Consider using other practices and management systems in conjunction with this practice to achieve a reduction of nitrate-nitrogen levels. Examples include NRCS CPSs Nutrient Management (Code 590), Cover Crop (Code 340), Drainage Water Management (Code 554), Denitrifying Bioreactor (Code 605), and Constructed Wetland (Code 656). Consider adding an envelope around the drain to improve exit flow. Refer to criteria in NRCS CPS Subsurface Drain (Code 606). Consider examining 4-feet soil cores at various intervals along the width and length of the buffer area when determining the existence of high conductivity soil layers that could provide preferential flow paths. For example, take soil cores to a depth of 4 feet at every 200 feet of buffer length and visually inspect them for sand and organic matter. Use Von Post method for assessment of organic matter.	**CONSIDERATIONS** Consider using other practices and management systems in conjunction with this practice to achieve a reduction of nitrate-nitrogen levels. Examples include NRCS CPSs Nutrient Management (Code 590), Cover Crop (Code 340), Drainage Water Management (Code 554), Denitrifying Bioreactor (Code 605), and Constructed Wetland (Code 656). Consider adding an envelope around the drain to improve exit flow. Refer to criteria in NRCS CPS Subsurface Drain (Code 606). Consider examining 4-feet soil cores at various intervals along the width and length of the buffer area when determining the existence of high conductivity soil layers that could provide preferential flow paths. For example, take soil cores to a depth of 4 feet at every 200 feet of buffer length and visually inspect them for sand and organic matter. Use Von Post method for assessment of organic matter.

For enhanced denitrification, consider field verification of topsoil organic matter content rather than reliance on rough (average or range) published data that is not specific for the site. For cost-effectiveness, consider locating the saturated buffer where it will intercept a subsurface drain outlet draining at least 15 acres. Consider installing observation wells in the buffer midway between the distribution pipe and the receiving channel or water body to facilitate water table documentation and water quality sampling. A saturated buffer may infiltrate less overland flow than a nonsaturated buffer. Where possible to maintain a water table at or near the buffer soil surface, planting the buffer to a mix of hydrophytic species suitable for wet soil conditions will enhance nitrate removal and increase soil carbon replacement at and near the soil surface. Installing a saturated buffer in locations where the water table is higher than the distribution line may result in the distribution line becoming a drain rather than distributing the drainage water from the system. This can happen where the land adjacent to the proposed saturated buffer is not adequately drained. Installation of this practice may enhance wildlife and pollinator habitats, with appropriate vegetation and management. Install an anti-seep collar if piping of trench earthfill along the bypass pipe is a concern. Consider measures to reduce the potential for root plugging of distribution lines by woody species. Set planted trees and shrubs back far enough that distribution lines will not be under the drip line of mature tree canopies. Plant herbaceous species in areas over distribution lines. If the riparian area is currently in trees, either establish an herbaceous zone outside the tree line for the water distribution area or remove only those trees that inhibit installation of the distribution line.	For enhanced denitrification, consider field verification of topsoil organic matter content rather than reliance on rough (average or range) published data that is not specific for the site. For cost-effectiveness, consider locating the saturated buffer where it will intercept a subsurface drain outlet draining at least 15 acres. Consider installing observation wells in the buffer midway between the distribution pipe and the receiving channel or water body to facilitate water table documentation and water quality sampling. A saturated buffer may infiltrate less overland flow than a nonsaturated buffer. Where possible to maintain a water table at or near the buffer soil surface, planting the buffer to a mix of hydrophytic species suitable for wet soil conditions will enhance nitrate removal and increase soil carbon replacement at and near the soil surface. Installing a saturated buffer in locations where the water table is higher than the distribution line may result in the distribution line becoming a drain rather than distributing the drainage water from the system. This can happen where the land adjacent to the proposed saturated buffer is not adequately drained. Installation of this practice may enhance wildlife and pollinator habitats, with appropriate vegetation and management. Install an anti-seep collar if piping of trench earthfill along the bypass pipe is a concern. Consider measures to reduce the potential for root plugging of distribution lines by woody species. Set planted trees and shrubs back far enough that distribution lines will not be under the drip line of mature tree canopies. Plant herbaceous species in areas over distribution lines. If the riparian area is currently in trees, either establish an herbaceous zone outside the tree line for the water distribution area or remove only those trees that inhibit installation of the distribution line. When practical, consider harvesting and removing green biomass to promote regrowth thus enhancing additional nitrogen removal from

When practical, consider harvesting and removing green biomass to promote regrowth thus enhancing additional nitrogen removal from the buffer area. Refer to NRCS CPS Forage and Biomass Planting (Code 512) for criteria on forage or biomass production.	the buffer area. Refer to NRCS CPS Forage and Biomass Planting (Code 512) for criteria on forage or biomass production.
PLANS AND SPECIFICATIONS At a minimum, include— • A plan view of the layout of the water distribution system and saturated buffer area. • Profiles of the existing drain, distribution pipe, and outlet channel. • Details of required structures for water level control. • Vegetation establishment requirements. • Construction specifications that describe site-specific installation requirements.	**PLANS AND SPECIFICATIONS** At a minimum, include— • A plan view of the layout of the water distribution system and saturated buffer area. • Profiles of the existing drain, distribution pipe, and outlet channel. • Details of required structures for water level control. • Vegetation establishment requirements. • Construction specifications that describe site-specific installation requirements.
OPERATION AND MAINTENANCE Prepare an operation and maintenance plan that includes— • Planned water level management and timing. • Inspection and maintenance requirements of the water control structures, distribution pipes, and contributing drainage system, especially upstream surface inlets. • Periodic removal of invasive trees or shrubs to reduce distribution line plugging. • If the site is to be monitored, monitoring and reporting requirements designed to demonstrate system performance and provide information to improve the design and management of this practice. At a minimum, record water levels (elevations) at the control structure, observation ports, and if used, observation wells. Record water levels biweekly	**OPERATION AND MAINTENANCE** Prepare an operation and maintenance plan that includes— • Planned water level management and timing. • Inspection and maintenance requirements of the water control structures, distribution pipes, and contributing drainage system, especially upstream surface inlets. • Periodic removal of invasive trees or shrubs to reduce distribution line plugging. • If the site is to be monitored, monitoring and reporting requirements designed to demonstrate system performance and provide information to improve the design and management of this practice. At a minimum, record water levels (elevations) at the control structure, observation ports, and if used, observation wells. Record water levels biweekly

when a water table is present and following precipitation events that result in high flows.	when a water table is present and following precipitation events that result in high flows.
REFERENCES Jaynes, D.B. and T.M. Isenhart. 2011. Re-saturating Riparian Buffers in Tile Drained Landscapes. A Presentation of the 2011 IA-MN-SD Drainage Research Forum. November 22, 2011. Okoboji, IA. Jaynes, D.B. and T.M. Isenhart. 2012. Re-saturating Riparian Buffers using Tile Drainage. Unpublished. Jaynes, D.B. and T.M. Isenhart. 2014. Reconnecting Tile Drainage to Riparian Buffer Hydrology. Journal of Environmental Quality 43:631-638. doi: 10.2314/jeq2013.08.0331. Advances in Agronomy 92:75-162.	**REFERENCES** Dickey, L., A. McEachran, C. Rutherford, C. Rehman, M. Perez, T. Groh, and T. Isenhart. 2021. Slope stability of streambanks at saturated riparian buffer sites. Journal of Environmental Quality 6:1430-1439. doi:1002/jeq2.20281. Jaynes, D.B. and T.M. Isenhart. 2014. Reconnecting Tile Drainage to Riparian Buffer Hydrology. Journal of Environmental Quality 43:631-638. doi: 10.2314/jeq2013.08.0331. Advances in Agronomy 92:75-162. Jaynes, D.B. and T.M. Isenhart. 2018. Performance of Saturated Riparian Buffers in Iowa, USA. Journal of Environmental Quality 48:289-296(2019). doi: 10.2134/jeq2018.03.0115. Johnson, G.M., L.E. Christianson, R.D. Christianson, M. Davis, C. Díaz-García, T., Groh, T.M. Isenhart, J. Kjaersgaard, R. Malone, L. Pease, and N. Rogovska. In press 2023. Effectiveness of saturated buffers on water pollutant reduction from agricultural areas. Journal of the ASABE. https://doi.org/10.13031/ja.15516