Bridging the Divide: Incorporating Interflow into Legal Discourse on Surface Water-Groundwater Interactions

Reshmina William and A. Bryan Endres***

INTRODUCTION

Despite the traditional separation of groundwater and surface water in academic and legal literature, both systems are in fact tightly interconnected. This artificial distinction persists due to the idea that groundwater movement takes place on a much larger timescale than surface water flows.[1] While this differentiation is true to some extent, it ignores the significant impact that subsurface flows can have on surface stream baseflow during droughts and peak flow floods.[2] In addition, the differentiation between surface water and groundwater flows has historically led to confusion over how to legally address water quality concerns in systems that handle subsurface flows. As discussed below, the pending Des Moines Water Works litigation[3] regarding pollution outflows from subsurface drainage infrastructures provides an excellent case study in the importance of legal distinctions between the different types of flow. Such distinctions may fundamentally alter the Clean Water Act's application in the agricultural context.

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* PhD Candidate, University of Illinois, Department of Civil and Environmental Engineering.
** Professor of Food & Agricultural Law, University of Illinois, Department of Agricultural and Consumer Economics.

1. Mehdi Ghasemizade & Mario Schirmer, *Subsurface Flow Contribution in the Hydrological Cycle: Lessons Learned and Challenges Ahead—A Review*, 69 ENVTL. EARTH SCI. 707, 708 (2013).
2. *Id*.
3. Bd. of Water Works Trs. of Des Moines v. Sac Cty. Bd. of Supervisors as Trs. of Drainage Dists. 32, 42, 65, 79, 81, 83, 86, No. 5:15-cv-04020, 2015 WL 1191173 (N.D. Iowa filed Mar. 16, 2015).

CHARACTERIZATION OF HYDROLOGIC REGIMES

Hydrologic regimes can be characterized by three different primary types of flow. Surface water, or *overland flow*, is simply water that runs off the surface of the ground. Because this layer of water is visible, it tends to be the most regulated of the three types. Groundwater is defined as water present below the surface, typically contained within porous materials or fractures in rock such as limestone karst systems.[4] However, groundwater can be subdivided further into different categories. The saturated zone is defined as the layer of soil below which the pores are filled completely with water.[5] The top of the saturated zone, where the pore-water pressure is equal to atmospheric pressure, is called the water table.[6] Water flowing through this saturated zone—*groundwater flow*—typically moves very slowly compared to overland flow, and thus can be fairly easily separated from overland flow.[7] Above the water table, the soil is no longer completely saturated. This layer is called the unsaturated, or vadose, zone. The soil in this layer typically provides the water uptaken by plant roots. The hydraulic properties of the unsaturated zone are also crucial in determining the quantities of water which infiltrate, percolate to groundwater, or run off.[8] *Interflow* is defined as the lateral movement of water through the vadose zone.

Interflow often is caused by flow through 'macropores' left behind by plant roots, or by sudden changes in soil permeability at a soil horizon. Small changes in soil properties can cause subsurface piping, or the build-up of a saturated wedge above the soil horizon surface,[9] which then moves laterally.[10] The processes driving interflow are illustrated in Figure 1. This water may move to the surface before re-infiltrating and becoming groundwater again.[11] As a result, interflow (often referred to as subsurface flow) provides a powerful example of the close connection between groundwater and surface water and the conceptual difficulty of treating these flows separately under different legal regimes.

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4. *See generally* R. ALLEN FREEZE & JOHN A. CHERRY, GROUNDWATER 2-4 (1979); Michael Bakalowicz, *Karst Groundwater: A Challenge for New Resources*, 13 HYDROLOGY J. 148 (2005).

5. *See* FREEZE & CHERRY, *supra* note 4, at 2-4.

6. *See* FREEZE & CHERRY, *supra* note 4, at 2-4.

7. Ghasemizade & Schirmer, *supra* note 1, at 708. It is important to note, however, that groundwater flows do provide an essential component of stream hydrologic regimes known as baseflow—a factor which can be important to take into consideration during times of low flow. *See id*.

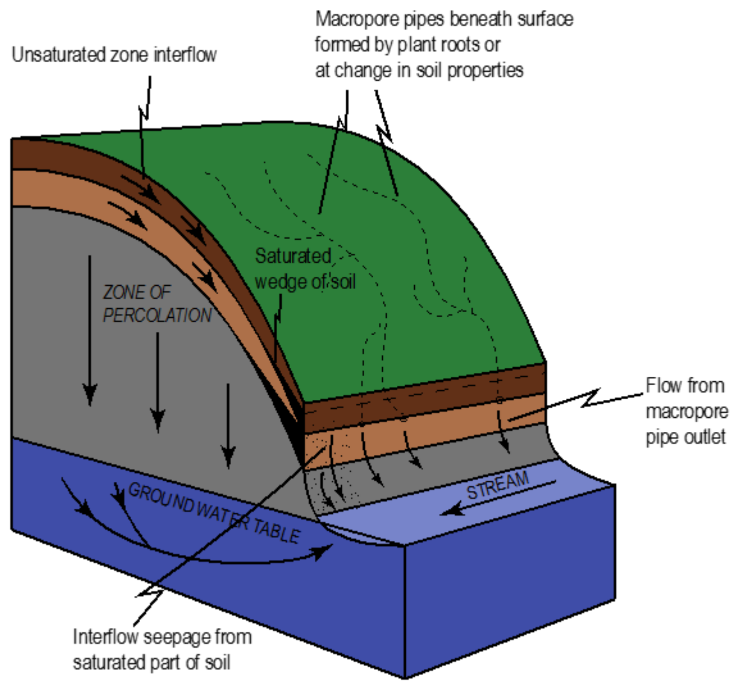
8. Ghasemizade & Schirmer, *supra* note 1, at 709-710.

9. A soil horizon is defined as a layer parallel to the ground surface which has physical properties different from the layers above and below it. *Soil Genesis and Development, Lesson 4—Soil Profile Development*, PLANT & SOIL SCIENCES ELIBRARY (last visited Feb. 23, 2017), http://passel.unl.edu/pages/informationmodule.php?idinformationmodule=1130447025&topicorder=4.

10. D. TARBOTON, RUNOFF GENERATION MECHANISMS IN RAINFALL-RUNOFF PROCESSES 4 (2003), http://hydrology.usu.edu/RRP/userdata/4/87/RainfallRunoffProcesses.pdf.

11. ANDY D. WARD & STANLEY W. TRIMBLE, ENVIRONMENTAL HYDROLOGY 122 (2nd ed. 2004).

Figure 1: Processes driving interflow



During major storm events, subsurface flow can contribute between 30-80 percent of surface runoff.[12] This water, which is observed as runoff in stream systems, is composed of a combination of pre-event water already stored in the catchment and event water, transported through the soil. In other words, storm flows typically are comprised of a combination of overland flow, groundwater flow and interflow. However, whether groundwater flow or interflow is the dominant means of flow transport during storm events is still subject to scientific debate.[13] Because of the complexity of hydrologic interactions in the real-world, research in the field is still on-going. Nevertheless, human activity has already been observed to have a significant effect on certain aspects of infiltration and interflow. Tile drainage, for example, is explicitly designed to

12. Ghasemizade & Schirmer, *supra* note 1, at 709.

13. *See, e.g.*, H.L. Cloke et al., *Using Numerical Modeling to Evaluate the Capillary Fringe Groundwater Ridging Hypothesis of Streamflow Generation*, 316 J. HYDROLOGY 141, 155 (2006); Aldo Fiori & David Russo, *Numerical Analyses of Subsurface Flow in a Steep Hillslope Under Rainfall: The Role of the Spatial Heterogeneity in the Formation of Hydraulic Properties*, 43 WATER RESOURCES RES. 1, 8 (2007).

create a fast flow route for excess water in the vadose zone through subsurface pipes. As a result, tile drainage has a significant impact on flows within hydrologic systems, impacting both stream baseflows and peak flows.[14]

LEGAL CONTEXT

Within the legal context, surface water quality is primarily subject to regulation under the Clean Water Act (CWA). However, courts remain divided on how to view the relation between groundwater and surface water, with the treatment of subsurface transport of contamination oscillating between the restrictive definition of a point source, or the broader jurisdictional definition of "waters of the United States."

From a jurisdictional perspective, *Rapanos v. United States*[15] highlighted multiple approaches to the incorporation of wetlands—and, by extension, groundwater—into the CWA jurisdictional framework. Justice Scalia, writing for a four-justice plurality, argued that CWA jurisdiction hinged on the physical properties of the wetland: only those wetlands with "continuous surface connection to bodies that are 'waters of the United States' . . . [are] covered by the Act."[16] On the other hand, Justice Kennedy's concurring opinion rested on the "significant nexus" test previously established in *Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers*.[17] Justice Kennedy argued that the requirement for a continuous surface connection was contrary to the legislative purpose: to protect the integrity of the nation's waters. Instead, Justice Kennedy advocated for a case-by-case approach, in which a wetland might be considered a "navigable water" if it "alone or in combination . . . significantly affect[ed] the chemical, physical and biological integrity of other covered waters more readily understood as 'navigable.'"[18]

This potentially more functional approach to jurisdictional issues[19] offers a wide range of questions with respect to water below the surface. Where in this classification does interflow fall? What about subsurface flows that cannot be easily partitioned between interflow and percolation to deeper groundwater?

14. Nicholas W. Thomas et al., *Numerical Investigation of the Spatial Scale and Time Dependency of Tile Drainage Contribution to Stream Flow*, 538 J. HYDROLOGY 651, 657 (2016). Moreover, in urban environments, the dramatic increase in impervious area has led to significant decreases in infiltration. Green infrastructure aims to utilize natural ecosystem services in order to increase infiltration, decrease surface runoff, and mitigate urban water quality and flooding issues. *See generally* M. BENEDICT & E. MCMAHON, GREEN INFRASTRUCTURE: LINKING LANDSCAPES AND COMMUNITIES (2006).

15. Rapanos v. United States, 547 U.S. 715 (2006).

16. *Id*. at 742.

17. Solid Waste Agency of N. Cook County v. U.S. Army Corps of Eng'rs, 531 U.S.159 (2001).

18. *Rapanos*, 547 U.S. at 780.

19. Robin Kundis Craig, *Justice Kennedy and Ecosystem Services: A Functional Approach to Clean Water Act Jurisdiction After* Rapanos, 38 ENVTL. L. 635, 640 (2008).

And how do man-made interfaces such as tile drainage and green infrastructure impact the legal portioning of surface water and groundwater?

Several recent cases offer conflicting approaches to these questions. In *Northern California River Watch v. City of Healdsburg*, the Ninth Circuit employed the *Rapanos* significant nexus test to determine that a pond used for wastewater "polishing" constituted a water of the U.S. through its hydraulic, ecological and chemical connection to the nearby Russian River via groundwater transport.[20] In *Yadkin Riverkeeper v. Duke Energy Carolinas LLC*, the district court held that the discharge of coal ash into unlined lagoons that were hydraulically connected to the nearby Yadkin River constituted a "point source" under the CWA.[21] The court noted that although the groundwater itself could not be considered a "water of the U.S.," it could still be considered a conduit for the pollutants to reach waters that were navigable in fact.[22] In reaching the *Yadkin* decision, the court noted two EPA documents in which the agency stated "[t]he [Clean Water] Act requires NPDES permits for discharges to groundwater where there is a direct hydrological connection between groundwaters and surface waters."[23] A similar ruling in *Hawai'i Wildlife Fund v. County of Maui* concluded that the injection of reclaimed wastewater into injection wells that were hydraulically connected to the ocean via groundwater seepage constituted a point source.[24] The court in *Northern California River Watch v. Mercer Fraser* provided the most succinct justification of the invocation of the CWA to deal with groundwater contamination, stating "it would hardly make sense for the CWA to encompass a polluter who discharges pollutants via a pipe running from a factory directly to a river bank, but not a factory who dumps the same pollutants into a man-made settling basin some distance short of the river and allows the pollutants to seep into the river via groundwater."[25] In sum, this line of cases stands for the proposition that groundwater may be a conduit for pollutants, thereby providing the crucial hydraulic connection between a point source and a water which is navigable in fact.

Tri-Realty v. Ursinus College, however, provides an interesting counterpoint. In this case, the court held that the migration of pollutants through diffuse groundwater is non-point source pollution, and thus not

20. N. California River Watch v. City of Healdsburg, 496 F.3d 993, 995 (9th Cir. 2007).

21. Yadkin Riverkeeper, Inc. v. Duke Energy Carolinas, LLC, 141 F. Supp. 3d 428, 444 (M.D. N.C. 2015).

22. *Id*. at 445.

23. *Id*. (citing EPA, National Pollutant Discharge Elimination System Permit Regulation and Effluent Limitations Guidelines and Standards for Concentrated Animal Feeding Operations, 66 Fed. Reg. 2960, 3015 (Jan 12, 2001); EPA, Revised National Pollutant Discharge Elimination System Permit Regulation and Effluent Limitations Guidelines for Concentrated Animal Feeding Operations in Response to the Waterkeeper Decision, 73 Fed. Reg. 70,418, 70,420 (Nov. 20, 2008)).

24. Hawai'i Wildlife Fund v. County of Maui, 24 F.Supp.3d 980, 1000 (D. Haw. 2014).

25. N. California River Watch v. Mercer Fraser Co., 2005 WL 2122052, at *2 (N.D. Cal. 2005).

covered by section 402 of the CWA.[26] However, the court did note that if the groundwater flow is channeled and directed at some point in time, then it becomes a point source.[27] In *Tri-Realty*, the contaminated groundwater was collected and directed through an underground stormwater pipe before emptying into an underground outfall pipe, which then discharged into a creek.[28] Thus, the flow in this particular case did constitute a point source. The court also drew interesting parallels between the mechanisms used to collect diffuse overland flow and those used to channel groundwater, such as underground pipes.[29]

Interflow, which is neither surface water nor groundwater, creates another layer of legal challenges. Although interflow is subject to a wide range of human intervention, it is not explicitly covered within the context of the CWA, with lower courts failing to reach consensus on the legal relationship between un-channeled groundwater transportation of pollutants and the contamination of navigable waters. As scientific understanding evolves, the role of interflow in contaminant transport will be of increased importance in legal arguments. However, the lack of legal distinction in what is meant by "subsurface flow" has led to great confusion. In *Friends of Santa Fe County v. LAC Minerals*, both of the expert witnesses were forced to clarify that "not all water that flows underground is technically 'groundwater,'" shifting the focus from a discussion of groundwater to a discussion of surface water.[30] As human intervention in natural flow paths becomes more prevalent, legal practitioners need to ensure that an adequate amount of specificity is used to define the type of flow under consideration. Post-*Rapanos*, practitioners should also work to specify a flow's functional impact on the hydrologic ecosystem, if any.

THE DES MOINES WATER WORKS LITIGATION AND BROADER POLICY IMPLICATIONS

The recent Des Moines Water Works (DMWW) litigation[31] illustrates the importance of the legal distinction between different types of flow. Specifically, DMWW revolves around the impact that drainage tiles have on nitrate loadings in the Raccoon River—a source of drinking water for the City of Des Moines. DMWW argues that because of the legal difference between "stormwater" and "groundwater," agricultural tile drain systems are not covered under the 1987 CWA agricultural stormwater discharge exemptions.

26. Tri-Realty Co. v. Ursinus Coll., 124 F. Supp. 3d 418, 465 (E.D. Pa. 2015).
27. *Id.* at 460.
28. *Id.* at 424.
29. *Id.* at 461-62.
30. Friends of Santa Fe County. v. LAC Minerals, Inc., 892 F. Supp. 1333, fn. 4 (D. N.M. 1995).
31. *See generally Des Moines Water Works Litigation Resources,* IOWA STATE UNIVERSITY (last visited Feb. 23, 2017), https://www.calt.iastate.edu/article/des-moines-water-works-litigation-resources (maintaining document repository and status updates regarding the litigation).

As a result, DMWW claims that tile drains are point sources (i.e. "discrete conveyances"), therefore triggering section 402 permitting requirements.

Under natural hydrologic conditions, very little nitrate is discharged from groundwater into streams. Tile systems, designed to artificially lower the water table by draining the saturated zone, make the land more suitable for agriculture. However, this process increases the amount of oxygen in the soil, which accelerates mineralization of organic material in the vadose zone and produces large amounts of nitrate. Mineralization is increased by higher temperatures, and is largely balanced out during the growing season by plant uptake. After the growing season, however, mineralization creates excess water-soluble nitrates in the soil that are transported via the drainage tiles into surface waters. As a result, up to 99.1% of nitrate loss is via groundwater flow, rather than surface runoff.[32]

From a legal perspective, the term "agricultural stormwater discharges" has yet to be clarified by the EPA, the CWA, or the Iowa Department of Natural Resources (IDNR). In the broader NPDES context, however, the EPA defines stormwater as "storm water runoff, snow melt runoff, and surface runoff and drainage."[33] In the hydrological engineering literature, runoff implies sheet flow, whereas drainage implies some form of channelization. However, both terms in this context typically apply to surface flows.[34] This definition appears to imply that the agricultural stormwater exemption is meant to apply to surface non-point source runoff, rather than subsurface flows in the vadose zone that are collected and channelized in tile drains.

In contrast, the EPA's regulation of urban stormwater discharges specifically excludes infiltration: ". . . the final regulatory language does not include infiltration in the definition of storm water. Such flows may be subject to appropriate permit conditions in industrial permits."[35] The reasoning given for this exemption was that contaminants can be both removed or added during their transport through the subsurface, implying that water quality can vary significantly between surface and subsurface flows.

Resolution of the DMWW case should clarify treatment of stormwater flows in the agricultural context. It also has the potential to alter the jurisdiction of the CWA. Past Supreme Court cases, including *Riverside Bayview* and *Rapanos*, have taken a functional approach to CWA jurisdiction, applying the Act in such a way as to further the purpose of the statute. In other words, the Court has typically sided with interpretations that protect the "physical,

32. W.A. Jackson et al., *Nitrate in Surface and Subsurface Flow from a Small Agricultural Watershed*, 2 J. ENVTL. QUALITY 480, 481 (1973).

33. Storm Water Discharges, 40 C.F.R. § 122.26(b)(13) (2016).

34. *See, e.g.*, FOOD AND AGRICULTURAL ORGANIZATION, *Watershed Management Field Manual* (2016), http://www.fao.org/docrep/006/t0099e/t0099e04.htm; *see also* Chamberlin v. Ciaffoni, 96 A.2d 140 (Pa. Super. Ct. 1953).

35. National Pollutant Discharge Elimination System Permit Application Regulations for Storm Water Discharges, 55 Fed. Reg. 47990, 47996 (Nov. 16, 1990) (codified at 7 C.F.R. § 122, § 123, and § 124).

chemical and biological integrity" of the nation's waters. In attempting to separate surface water from groundwater in order to work around the agricultural stormwater discharge exemption, the DMWW's arguments run the risk of once again neglecting the hydrologically important role of interflow – a form of flow which is neither surface nor groundwater.

While the water quality based arguments advanced by the DMWW make sense in this particular case, they could set a potentially problematic precedent by encouraging further division of what is already a highly partitioned approach to managing water quality under the CWA. The physical division between surface water and groundwater remains blurred, due to the complex interactions between surface runoff, interflow and deep percolation. These processes change with space and time, and are heavily impacted by human interactions with the natural environment. From the perspective of water quality and flood management, interflow, groundwater, and surface water need to be considered holistically within the same legal paradigm rather than divided into increasingly discrete statutory regimes and their attendant exemptions. Unfortunately, the CWA, in its current form, does not accommodate this approach. Nonetheless, increased scientific understanding of the degree of connectivity among various water flows argues for a re-evaluation of agricultural stormwater exemptions, as well as the broader management of anthropogenic impacts in both urban and rural contexts.