The National Hydrography Database as a Framework for Analyzing Surface Water Interactions

Idaho Diversions Pilot Project

Danielle Bruno-Favreau[i], Linda Davis[ii], Kristiana Elite[iii], Jeffrey Simley[iv]

ABSTRACT/SUMMARY

Over the last several years, it has become important to understand where water is being withdrawn, transferred, and consumed, as well as where it is returning to the system, known as return flows. These diversions are important in providing water for crops, drinking water, and aquifer recharge, and return flows affect water quality, recreation and fisheries. In an effort to better understand these relationships and improve the National Hydrography Database (NHD) representation of diversions, the United States Geological Survey (USGS) conducted a pilot project in Idaho with the Idaho Department of Water Resources (IDWR). The pilot project examined diversions for a selected area and analyzed how they may be identified within the NHD.

The State of Idaho, U.S.A. has over 3.4 million acres of land that are irrigated with surface water diversions. With over 95,000 miles of streams and 15,000 miles of canals in Idaho, as well as numerous dams, reservoirs, pipelines and flumes, the water delivery system is complex and extensive.[v] The Milner-Gooding Canal in south-central Idaho has an initial capacity of 2700 cubic feet per second and furnishes full water supply to 20,000 acres and supplemental supply for 78,667 acres.[vi] The area served by the Milner-Gooding Canal System was selected as the pilot project area.

The NHD depicts how water moves across the landscape and can be used to illustrate and model water interactions. The NHD can represent both natural and man-made features. This includes the location of a water withdrawal from the natural drainage system, the point(s) of delivery for the withdrawn water and in some cases where a portion of the diverted water is returned to a natural drainage system after use.

The NHD linework of the area served by the Milner-Gooding Canal system was overlaid on National Agriculture Imagery program (NAIP) 1 meter imagery. Using the imagery, lateral names, and local knowledge of the system, three types of diversion actions were identified: withdrawing, receiving and returning. A location where a canal or lateral diverted from a natural source or split into a lateral was considered a point of withdrawal. If water is added to the network or landscape, it was a point of receiving. A point of return is where water reaches a groundwater or surface-water source after release from the point of use and thus becomes available for further use.

Withdrawing, receiving, and return locations were successfully identified using this methodology. Project challenges included defining the terms withdrawing, receiving, and return, differentiating between a receiving vs. returning location, and determining where a lateral actually terminates. As use of the NHD has expanded, the need for the NHD Model to indicate where water is returning to a natural system or where it is being consumed has become more pronounced. The challenges encountered during this project have provided discussion points for NHD Model adjustments.

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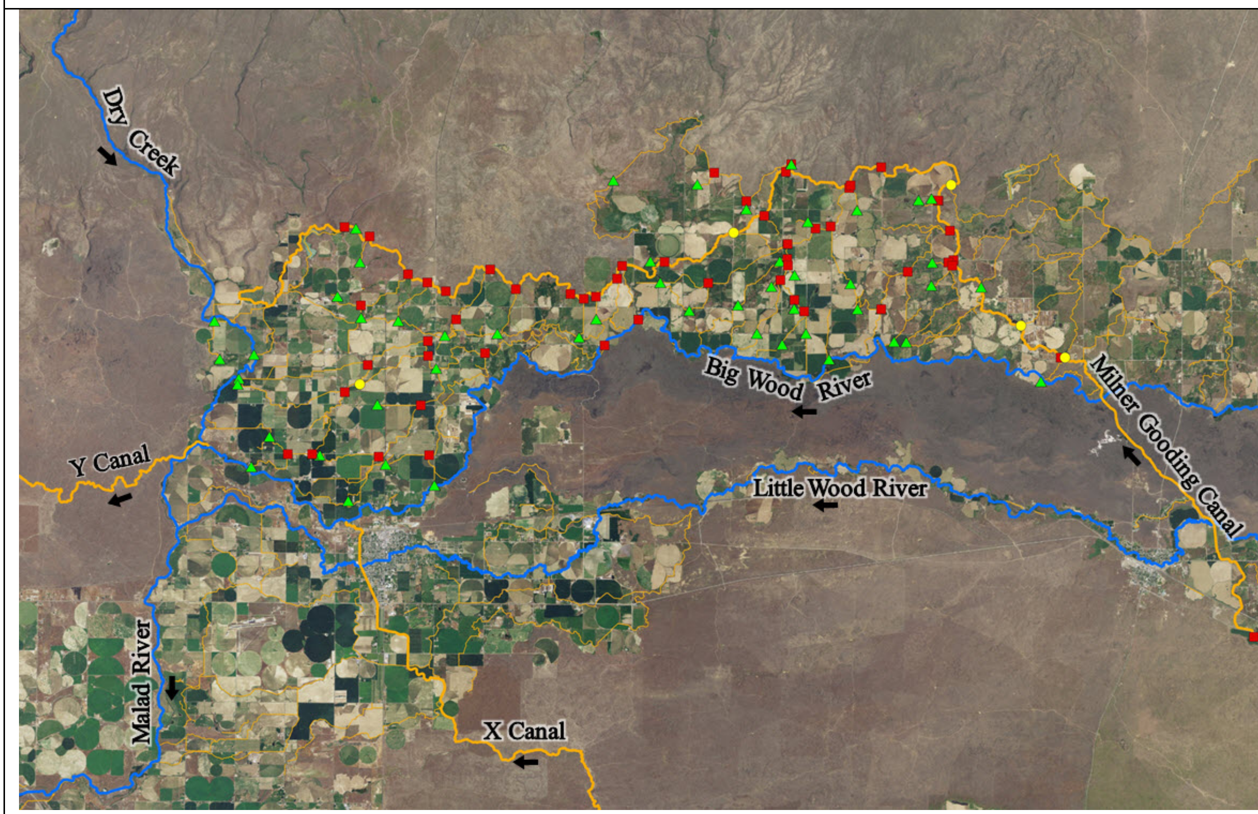
Fig. 1 Lands served by the Milner Gooding Canal.



Legend: Red box = withdrawing point, green triangle = receiving point, yellow circle = returning point

INTRODUCTION

Alterations of natural water flow can have a direct impact on water quality, water availability, water-use, and the health of an ecosystem. It has become important to understand where water is being withdrawn, transferred, and consumed, and where water is returning to the system, known as return flows. Return flows can contribute to flow levels critical to power generation, recreation, and fish habitat. In addition, water returning to a stream after passing through fertilized fields can be a source of nitrate and phosphorous pollutants. Changes in the amount of water returning to a system can be affected by changes in irrigation practices, such as going from flood irrigation to sprinkler irrigation, or by the lining or piping of canals. In an effort to better understand these relationships, the United States Geological Survey (USGS) conducted a pilot project in Idaho with the Idaho Department of Water Resources (IDWR).

Idaho's Water Resources

Water, a scarce resource in Idaho and throughout the Western U.S., is important to many competing water users including the agricultural, urban, recreational, and fisheries sectors. It may seem difficult to believe that water would be scarce in a state with over 95,000 miles of streams and rivers, and more than 2,000 natural lakes[xi]. Scarcity is more easily seen when one realizes that annual precipitation accounts for over 75 percent of Idaho's water supply[xii] but, Idaho's average annual precipitation is 22 inches per year with the Snake River Basin averaging 18 inches per year[xiii].

Idaho is the second largest water user in the U.S., only behind California, with the majority of water used in agriculture.[xiv] Another major industry in Idaho dependant on water is tourism. Many people visit Idaho to enjoy its natural wonders, including Hells Canyon, the deepest river gorge in America, and Shoshone Falls, the "Niagara Falls of the West". Idaho has excellent fishing opportunities including Chinook salmon and Steelhead trout runs, and Idaho's whitewater rafting locations have more whitewater river miles than anywhere in the lower 48 states.[xv] Idahoans are also heavily dependent on its water for power. Nearly 90% of Idaho's power is hydroelectric with 136 hydroelectric plants generating an annual average of 11 billion kilowatt hours.[xvi]

Idahoans also depend on groundwater resources. Although groundwater comprises only 22 percent of Idaho's total water use, it accounts for nearly 95 percent of Idaho's drinking water.[xvii] One of Idaho's important aquifers is the Eastern Snake Plain Aquifer (ESPA). ESPA recharge occurs primarily via irrigation percolation, canal and stream losses, and subsurface flow from surrounding areas.[xviii] Natural discharge from the ESPA is via the Thousand Spring Reach, contributing 70 percent of the Snake River flow between the Milner Dam and King Hill.[xix] This flow is critically important as irrigation diversions at Milner Dam can reduce the Snake River flows to zero in an average year.[xx]

Southern Idaho has a high desert climate with significant amounts of Federal land. At the turn of the century, those characteristics made Idaho a prime candidate to reap the benefits of the 1902 Reclamation Act and the Carey Act of 1894.[xxi] The primary goal of this reclamation program was to develop the arid west by providing farming opportunities by using the sale of federal lands to finance water development projects.[xxii] The Carey Act of 1894 allowed private companies to construct irrigation systems and profit from the sale of water. As a result of these Acts, Idaho has over 3.4 million acres of land that are irrigated with surface water diversions through over 15,000 miles of canals and ditches.

One of the oldest reclamation projects is the Minidoka project. This project began in 1904 with the construction of the Minidoka Dam on the Snake River.[xxiii] One of the major canals built as part of the Minidoka Project was the Milner-Gooding Canal. The Milner-Gooding Canal has an initial capacity of 2700 cubic feet per second and furnishes full water supply to 20,000 acres and supplemental supply for 78,667 acres through its system managed by the American Falls Reservoir District No. 2 (AFRD2).[xxiv]

The AFRD2 system was selected for this pilot project because:

- Current linework for the AFRD2 system is available and is being used to update the NHD
- AFRD2 is a typical southern Idaho irrigation system in that the system receives inputs from multiple water sources (one being the Snake River), distributes water to multiple locations for water use, transports water to other irrigation districts and also returns some water back to the Snake River.
- AFRD2 is in the western end of the Eastern Snake Plain Aquifer (ESPA) and is currently involved in an aquifer recharge project

- Transportation of water through the Milner-Gooding Canal results in cross-subbasin water delivery

<u>The National Hydrography Dataset</u>

The National Hydrography Dataset (NHD) depicts how surface water moves across the landscape. Withdrawal features or structures associated with withdrawals such as dams, gates, and gauges were commonly found on the traditional topographic map and hence are features in the NHD. These withdrawal features are common starting or ending points for much water related analyzes. These withdrawal features can represent diversion systems which are imperative to understanding surface water in the arid west.

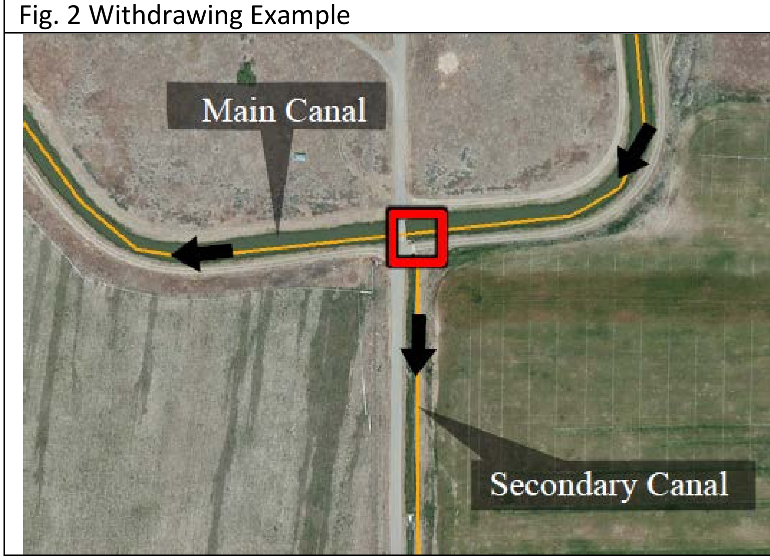
Although the NHD can be used to make maps representing surface water, its modeling power resides in the geometric network. This geometric network enables analysis of upstream and downstream characteristics and the ability to discover features along the network. For example, analyses such as locating all surface water diversions (withdrawals) on a river or determining the total river miles upstream from a reservoir are possible.

Many local water managers are interested in looking at the efficiencies of their systems in water delivery from the point of withdrawal to their customers. They are also interested in estimating the amount their system may be providing to ground water recharge through seepage. Good spatial data attached to the NHD can help answer some of these questions. The NHD strives to be a scalable model that can accommodate regional and local analysis needs. The USGS has conducted some large scale projects where returns and receiving points were described using a point event feature class. A similar methodology will be used to describe return/receiving points along the AFRD2 system.

METOHODOLOGY

The NHD linework of the AFRD2 system was overlaid on I meter National Agriculture Imagery Program (NAIP) imagery. Using the imagery, lateral names, and local knowledge of the system, three types of diversion actions were identified: withdrawing, receiving and returning. A point feature was then created to identify each one of these actions.

Fig. 2 Withdrawing Example



Definition of terms

For this pilot project, the following definitions were used:

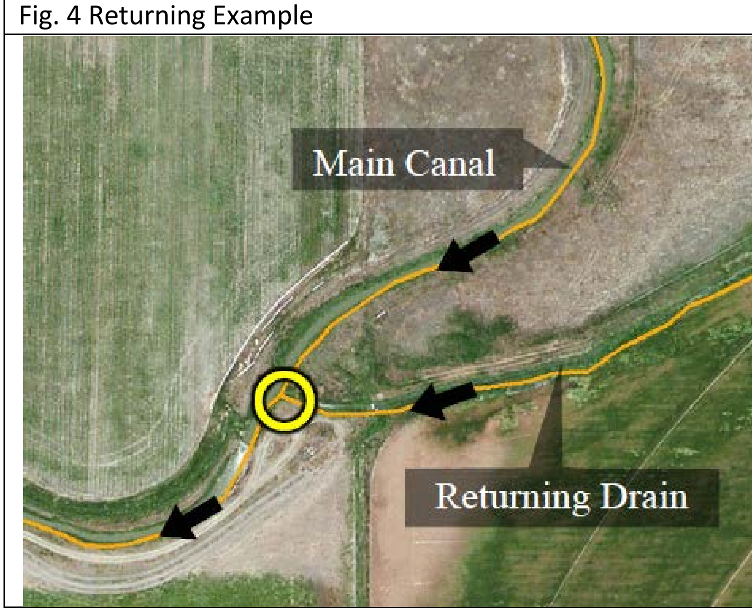
- *Withdrawing (Fig. 2)*
  A point on the surface water network where water is removed from the network, typically through a conveyance such as a Canal/Ditch or Pipeline.

- *Receiving (Fig. 3)*
  A point on the surface water network where water is added to the network or landscape, typically through a conveyance such as a Canal/Ditch or Pipeline.

Fig. 3 Receiving Example

- *Returning (Fig. 4)*
  A point where water reaches a groundwater or surface-water source after release from the point of use and thus becomes available for further use.

Fig. 4 Returning Example



Capture conditions and placement of points

- ***Withdrawing***
  A withdrawing point was created at the junction of the flowline that the water was being withdrawn from and the flowline the withdrawn water was being placed into. These points were placed at the start of every lateral to indicate the beginning of a new diversion. The lateral was then followed until it either terminated at a receiving point or a returning point. In addition, there was an intention to pair every withdrawing point (start point of a lateral) with a single final receiving point (end point of that lateral). This intention uncovered challenges which are discussed in the *Pilot Project Challenges* section.

- ***Receiving***
  A receiving point was created at the end of every lateral which was often a pivot or a flood irrigated field. Again, this also uncovered several challenges (see *Pilot Project Challenges* section).

- ***Returning***
  A returning point was created at the location where it appeared water was either being placed back into a natural or engineered flowline.

FINDINGS

This pilot project allowed us to identify withdrawing, receiving, and returning locations using an established method. It also demonstrated how this method could successfully be implemented at a local level.

As noted in the Methodology section, the intention was to pair every withdrawing point (start of a lateral) with a receiving point (end of that lateral). In attempting to do so, it was uncovered that on occasion it was challenging to determine if a point should be classified as receiving or returning (see Pilot Project Challenges).

Point Features Identified:

- Withdrawing - 153
- Receiving - 123
- Returning – 17*
  * If every withdrawing point had its receiving pair, there should be an equal amount of receiving and withdrawing points (i.e. 153 points). In reality, we identified 123 receiving points. This was due to the fact that it was not always clear if a point should be classified as that of receiving or of returning. This is discussed further in the next section (Pilot Project Challenges).

Pilot Project Challenges

Definition of terms:

Professionals from different aspects of water management and study may use terms relating to water diversions differently. For example, one professional would call a return the location where water withdrawn from a natural system returns to a natural system through a conveyance structure, whereas another would call a return a collection drainage from a field.

Differentiating between a receiving vs. returning location:

The challenges here were two-fold.

1. The first challenge was in putting the two definitions, receiving and returning, into practice. This revealed a need to further clarify the differences between the two types of actions.

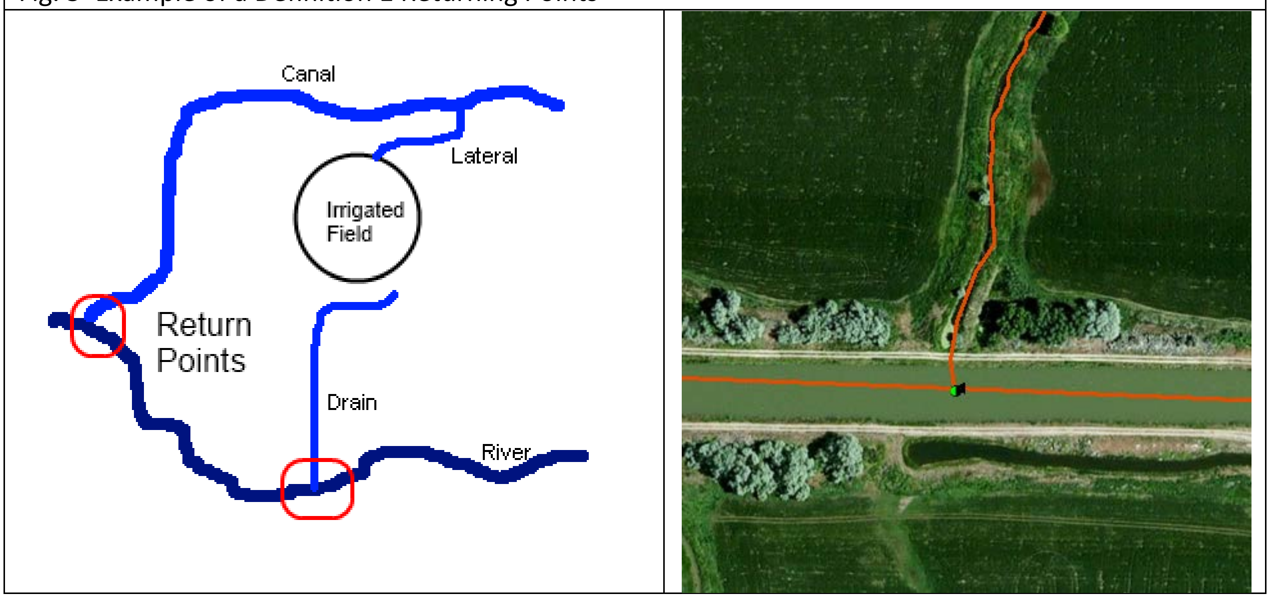
    - Return Definition 1 (Fig. 5)

      Another definition of a return would be a canal that withdraws water from a river, travels a distance with several laterals withdrawing water from it along the way, then terminates at a river, canal or waterbody and whatever water was not withdrawn along the way is placed back into that flowline. This example shows water that is simply being moved from one location to another. Some type of consumptive use is not a requirement of this definition.

        - It does not matter if the water had been used or not but rather if any previously diverted water is placed back into a water body/flowline (either natural or engineered) constitutes a point of return.

        - This was the definition used for this study.

Fig. 5 Example of a Definition 1 Returning Points



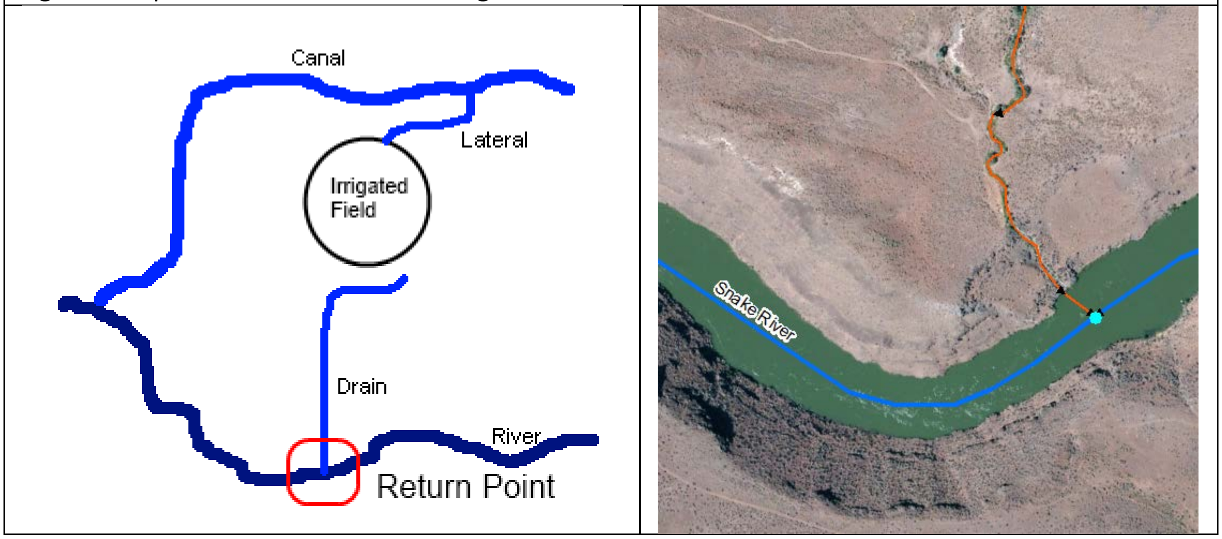
- Return Definition 2 (Fig. 6)

For example, if a lateral ended by adding its water into another lateral, was that defined as a receiving or returning point? Some would say a returning point is defined only as the location where waters are placed back or "returned" after being put to beneficial use. This definition requires that the waters needed to be used in order to be considered returned water.

- If water was diverted to irrigate a number of fields and what was not used (either absorbed by the plants, transpired or soaked into the ground) collected into a drain and returned back into either a river/stream or into another canal/lateral, this may be called a return by some.

- Water that is not used or consumed but just transports through the system is not a return.

Fig. 6 Example of Definition 2 Returning Point



2. The second challenge was in understanding what was happening on the ground based solely on the aerial imagery and some knowledge of the canals/laterals.

Determining where a lateral actually terminates:

Some laterals appeared to terminate at areas that were not obvious areas of receiving. The NHD Flowline feature can be used to infer use locations if it terminates in an irrigation field or other area of water use. Also, the downstream intersection of where a canal or drain intersects a stream can be used to infer a location where water returns to a natural system. There is not a requirement for a NHD flowline to terminate in a defined area. Incomplete or missing features within the NHD, such as pipelines that may not be visible from imagery may make a return location difficult to determine.

CONCLUSIONS

Critical components of a diversion system are where water is withdrawn, where it is used, and where it returns to the natural system. At the completion of this project, the ability to identify locations of withdrawing, receiving, and returning at this scale (local canal system) using an established methodology was confirmed.

These identified locations can be used in water analysis for:

- Use with the NHD geometric network as starting points or barriers for network analysis
- Cartographic indication of areas of water transfer or use
- Combining with other data, especially water measurement data

The challenges that arose from this pilot project became input for the discussion to modify the NHD's current data model (v 2.1) for representing these diversion actions (withdrawing, receiving and returning). The NHD recognized the challenges of the current data model and is discussing a simplified approach to representing these actions. This new discussion involves the desire to create a revised model that is clear, simple, can be applied consistently across the nation and still possess the power to assist the water resources community to gain knowledge and help make informed decisions.

ACKNOWLEDGEMENTS

Thank you to the staff at the American Falls Reservoir District No.2/Big Wood Canal Company for without their help, the updated linework for the AFRD2 system would not exist.

END NOTES

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