Ground Water and Surface Water Nitrate Patterns in the Lewiston Basin (Nez Perce County, Idaho)

1976–2018

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Abbreviations, Acronyms, and Symbols

$^{0}/_{00}$	per mil (units of $\delta^{15}N$)
bgs	below ground surface
BMP	best management practice
cfs	cubic feet per second
DEQ	Idaho Department of Environmental Quality
EPA	United States Environmental Protection Agency
GWMA	Ground water management area
IDAPA	refers to citations of Idaho administrative rules
IDPES	Idaho Pollution Discharge Elimination System
IDWR	Idaho Department of Water Resources
ISWCC	Idaho Soil and Water Conservation Commission
L	liter
lb	pound
LOID	Lewiston Orchards Irrigation District
MCL	maximum contaminant level
mg	milligram
$\delta^{15}N$	nitrogen stable $^{15}N/^{14}N$ stable isotope ratio
N	nitrogen
NO_3	nitrate
NO_2	nitrite
NPA	nitrate priority area
NPDES	National Pollution Discharge Elimination System
NPSWCD	Nez Perce Soil and Water Conservation District
TMDL	total maximum daily load
WAG	watershed advisory group

Executive Summary

This report summarizes information about nitrate contamination in the Lewiston Basin. Nitrate is a form of nitrogen, an element essential for plant and animal growth. Surface water and ground water nitrate contamination is typically caused by human land use patterns. Nitrate from soil, fertilizers, livestock manure, septic systems, and other sources can enter surface water, where it can cause nuisance algal growth and affect aquatic life. Nitrate can also enter ground water, where it may contaminate drinking water supplies and increase human health risks.

Surface water and ground water nitrate contamination is widespread within the Lewiston Basin and has several significant consequences:

- Nitrate concentrations in the Saddle Mountains aquifer (0–250 feet below ground surface [bgs]) exceed the Idaho and US Environmental Protection Agency (EPA) threshold (10 milligrams nitrogen per liter) for protecting human health. Some basin residents use the Saddle Mountains aquifer as a drinking water source. Infants younger than 6 months old are especially sensitive to nitrate poisoning, which can cause serious illness or death (Mahler et al. 2007).
- Ground water nitrate contamination has affected private domestic water supplies. Several residents told the Idaho Department of Environmental Quality (DEQ) they stopped using a private well as a drinking water source because well nitrate concentrations were high, and they were concerned about associated health risks.
- Although nitrate contamination primarily occurs within the shallow Saddle Mountains aquifer (0–250 feet bgs), nitrate can also contaminate some deeper wells. Some old wells completed in the deep Grand Ronde aquifer (which is not contaminated by nitrate) do not have well casings to prevent nitrate-rich water from the shallower Saddle Mountains aquifer from entering the wells. Water drawn from such wells may be a mixture of contaminated and clean water and have elevated nitrate concentrations. DEQ and the Idaho Department of Water Resources (IDWR) confirmed this situation has occurred in at least one well in the Lewiston Basin. For new wells, IDWR requires well casing installed to prevent mixing of water from different aquifers.
- Local, state, and federal agencies have allocated taxpayer dollars to address nitrate contamination. Examples include, but are not limited to, bonds issued by the City of Lewiston Urban Renewal Agency to finance a sewer line extension, surface water and ground water monitoring projects conducted by DEQ, and allocating EPA Clean Water Act §319 grant funds to stream restoration projects.

Potential nitrate sources in the basin include wildlife, soil organic matter, fertilizers, livestock, stormwater discharges, and septic systems. DEQ has confirmed septic systems are one source of nitrate to ground water and surface water. Nitrogen fertilizer applied to cropland likely is a significant nitrate source to the Saddle Mountains aquifer and surface water. The relative contribution of different nitrate sources is not clear and merits further investigation. This report documents nitrate patterns in surface water and ground water and identifies knowledge gaps relevant to nitrate management.

To reduce nitrate contamination, nitrogen inputs to ground water and surface water need to be reduced. To address nitrate pollution from agriculture, the Idaho Soil and Water Conservation Commission (ISWCC) will need to work with landowners on a voluntary basis to implement

agricultural best management practices. Idaho Code §39-3602(9) identifies ISWCC as the designated management agency for addressing nonpoint source pollution from grazing and agriculture, and Idaho Code §39-3611(10) requires state agencies to work with landowners on a voluntary basis. Addressing nitrate sources associated with development would require action by local government entities, such as minimum lot size requirements for installation of septic systems or sewer line installation. For example, the City of Lewiston recently extended a sewer line into the eastern Lewiston Orchards to decrease nitrate inputs from septic systems.

In 2019, DEQ will hold several public meetings with a watershed advisory group (WAG) composed of local interests affected by water quality management. DEQ will seek input from the WAG, Lewiston Plateau Ground Water Management Area Citizens Advisory Committee, local government entities, watershed residents, and other stakeholders on approaches for addressing nitrate contamination. This document was developed in part to summarize available information for stakeholders in this process.

1 Introduction

This report addresses surface water and ground water nitrate contamination in the Lewiston Basin (Nez Perce County, Idaho, Figure 1). Nitrate is a form of nitrogen, an element essential for plant and animal growth. Surface water and ground water nitrate contamination is typically caused by human land use patterns. Nitrate from soil organic matter, fertilizers, livestock manure, septic systems, and other sources can enter surface water, where it can cause nuisance algal growth and affect aquatic life. Nitrate can also enter ground water, where it may contaminate drinking water supplies and increase human health risks. Nitrate contamination in surface water and ground water is widespread within the Lewiston Basin and has several significant consequences:

- ***Human health risks***. Nitrate concentrations in the Saddle Mountains aquifer (0–250 feet below ground surface [bgs]) exceed the Idaho and US Environmental Protection Agency (EPA) threshold (10 milligrams nitrogen per liter [mg N/L]) for protecting human health. Some basin residents use the Saddle Mountains aquifer as a drinking water source. Consuming water with nitrate-nitrogen concentrations greater than 10 mg N/L can increase health risks for infants, people in poor health, and the elderly. Infants younger than 6 months old are especially sensitive to nitrate poisoning, which may cause serious illness or death (Mahler et al. 2007). Illness occurs when nitrate (NO_3) converts to nitrite (NO_2) in the body. Nitrite reduces the amount of oxygen in blood, causing shortness of breath and blueness of the skin (i.e., blue baby syndrome or methemoglobinemia). Adults in poor health and the elderly can also be susceptible to health problems from short-term nitrate exposure.
- ***Impaired Domestic Water Supply.*** Ground water nitrate contamination in the Lewiston Basin caused some residents to stop using private wells drawing from the Saddle Mountains aquifer as a drinking water source. Several residents told DEQ they stopped using a shallow private well for drinking water because nitrate concentrations were high in their well, and they were concerned about health risks. For many properties outside the City of Lewiston boundary, private wells are residents' primary drinking water source.
- ***Aquifer cross-contamination.*** Although nitrate contamination primarily occurs within the shallow Saddle Mountains aquifer (0–250 feet bgs), nitrate can still contaminate some deeper wells. Some old wells in the deep Grand Ronde aquifer (which is not contaminated by nitrate) do not have well casings to prevent nitrate-rich water from the shallower Saddle Mountains aquifer from entering the wells. Water drawn from such wells may be a mixture of contaminated and clean water and have elevated nitrate concentrations. The Idaho Department of Environmental Quality (DEQ) and the Idaho Department of Water Resources (IDWR) confirmed this situation has occurred in at least one well in the Lewiston Basin. For new wells, IDWR requires installing well casings to prevent mixing of water from different aquifers.
- ***Allocation of taxpayer dollars by state, federal, and local government agencies.*** Nitrate contamination prompted development of water quality improvement plans or total maximum daily loads (TMDLs) for Lindsay and Tammany Creeks. TMDLs specify maximum nitrate inputs to surface water from all sources that can occur while still meeting state surface water quality standards. DEQ also designated the Lindsay Creek

Nitrate Priority Area (NPA) (Figure 1) to address nitrate contamination in ground water. NPAs are areas where elevated levels of nitrate in ground water, and focused ground water monitoring and protection are needed to reduce contamination and associated health risks (DEQ 2014). DEQ monitors wells within the NPA annually and periodically monitors nitrate in surface water.

At the federal level, the Clean Water Act requires EPA to review and approve TMDLs. EPA approved the Lindsay Creek and Tammany Creek TMDLs in 2007 and 2010, respectively. Any subsequent TMDL modifications would also require EPA approval. In addition, DEQ used federal Clean Water Act §319 nonpoint source management program grant funds provided by EPA to fund two projects in Lindsay Creek and on project in Tammany Creek totaling $678,781 that help address nitrate contamination.

At the local level, the Nez Perce Soil and Water Conservation District (NPSWCD) allocated staff time and resources to developing a TMDL implementation plan for agriculture (NPSWCD 2008) and assisting landowners with land use best management practices (BMPs). In 2018, the Lewiston Urban Renewal Agency also issued over 2 million dollars in bonds to fund an extension of the City of Lewiston's sewer line into the eastern Lewiston Orchards. The purpose of the project was to reduce nitrate inputs from septic systems within the Lindsay and Tammany Creek watersheds and promote economic development in the Lewiston Orchards area (City of Lewiston URA 2017).

2 Objectives

This report summarizes information about nitrate contamination in the Lewiston Basin area for area stakeholders, including the Lindsay Creek Watershed Advisory Group (WAG), Lewiston Plateau Ground Water Management Area (GWMA) Citizens Advisory Committee, and area residents. Report objectives are as follows:

- Document nitrate patterns in Lewiston Basin ground water and surface water.
- Document the recent history of ground water and surface water quality monitoring and management efforts in the Lewiston Basin.
- Identify information gaps relevant to nitrate management.

Appendix A presents a water quality monitoring and management timeline for the Lewiston Basin.

3 Area Description

The Lewiston Basin is located in Nez Perce County, Idaho. For this report, the Lewiston Basin includes the GWMA and Tammany Creek and Lindsay Creek watersheds (Figure 1). The basin includes the City of Lewiston as well as residential subdivisions and rural residences within Nez Perce County. The City of Lewiston had a population of 31,894 people in the 2010 census. Within the basin, nonirrigated cropland (primarily wheat and legumes) is the dominant land use, and many small ranches and livestock operations exist.

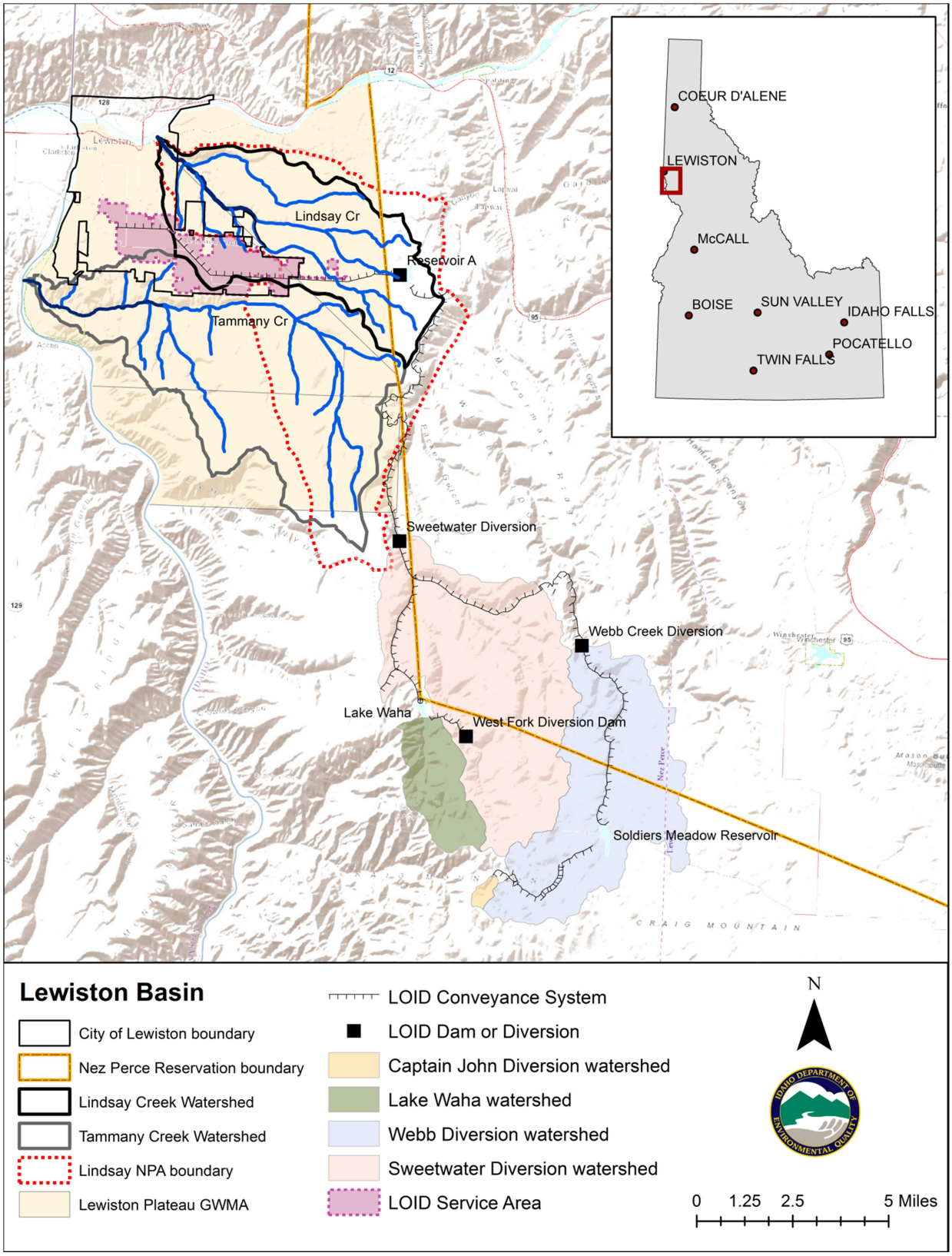

Figure 1. Lewiston Basin study area and administrative boundaries.

Surface water bodies in the Lewiston Basin include Tammany Creek, Lindsay Creek, and Mann Reservoir (also known as Reservoir A) (Figure 1). Tammany Creek is a 3rd-order tributary to the Snake River with stream flows of 2–4 cubic feet per second (cfs) in spring, and <1 cfs in summer at the mouth. Lindsay Creek is a 3rd-order tributary to the Clearwater River with flows of 5–7 cfs in spring and 1–2 cfs in summer at the mouth. Both streams begin in residential developments and cropland at elevations ≥1,700 feet above mean sea level (MSL) and bisect basalt canyons before reaching their mouth at approximately 750 feet above MSL. Both water bodies have a perennial main stem and some upper reaches that are intermittent. Mann Reservoir stores runoff conveyed from a series of upstream diversion dams and reservoirs (Figure 1). Water from Mann Reservoir is conveyed to the Lewiston Orchards Irrigation District (LOID) service area though a pipe system and is used by residents to water lawns and livestock, and for fire protection.

Tammany and Lindsay Creeks are fed by precipitation, ground water, and irrigation inputs. Average annual precipitation in Lewiston is 12.3 inches (NOAA 2018). Most precipitation occurs in fall, winter, and spring, with very limited summer precipitation. Springs and seeps are present along basalt canyon walls in both watersheds; ground water inputs to stream flow are thought to be substantial, but the relative percent contribution of ground water to stream flow has not been quantified. Irrigation water applied through the LOID service area is also source to ground water and surface water within the Lewiston Basin.

Multiple aquifers lie below the Lewiston Basin (Figure 2 and Figure 3). In each aquifer, water is present in relatively thin (5–20 feet) vertical zones of fractured basalt (Neely 2018). The Saddle Mountains aquifer spans 0–250 feet bgs and is composed of multiple layers of fractured basalt. A sedimentary interbed called the Sweetwater Formation sits below the Saddle Mountains aquifer and separates it from a second lower fractured basalt aquifer, the Wanapum aquifer. A sedimentary interbed called the Vantage Formation sits below the Wanapum aquifer and separates it from the Grande Ronde aquifer. Water from the Saddle Mountains likely percolates downward through basalt fractures and may be a source of water to the Wanapum aquifer, but the extent of hydrologic communication is not clear (Daniel Sturgis, IDWR, personal communication, November 14, 2018). The Saddle Mountains aquifer, and possibly the Wanapum aquifer, are sources of springs that provide ground water inputs into Lindsay and Tammany Creeks. Below the Wanapum aquifer and Vantage interbed, the Grande Ronde aquifer has three distinct vertical strata from three separate basalt flows. The Grande Ronde aquifer is part of a large deep regional aquifer system that is likely recharged by the Snake and Clearwater Rivers (Ralston 2017; Neely 2018). The Saddle Mountains, Wanapum, and Grande Ronde aquifers are all used by basin residents for drinking water and irrigation.

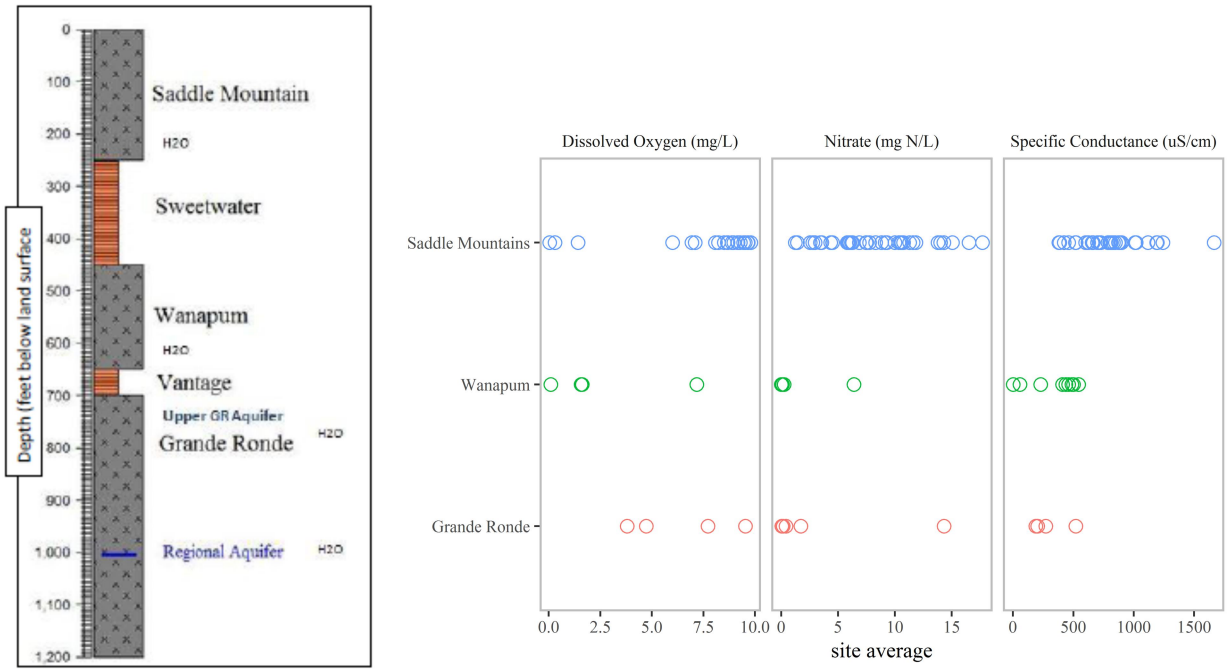

Figure 2. Ground water strata diagram (Neely 2017). Average dissolved oxygen, nitrate, and conductivity concentrations for wells and springs sampled by DEQ within the Lindsay Creek NPA and Lewiston Plateau GWMA.

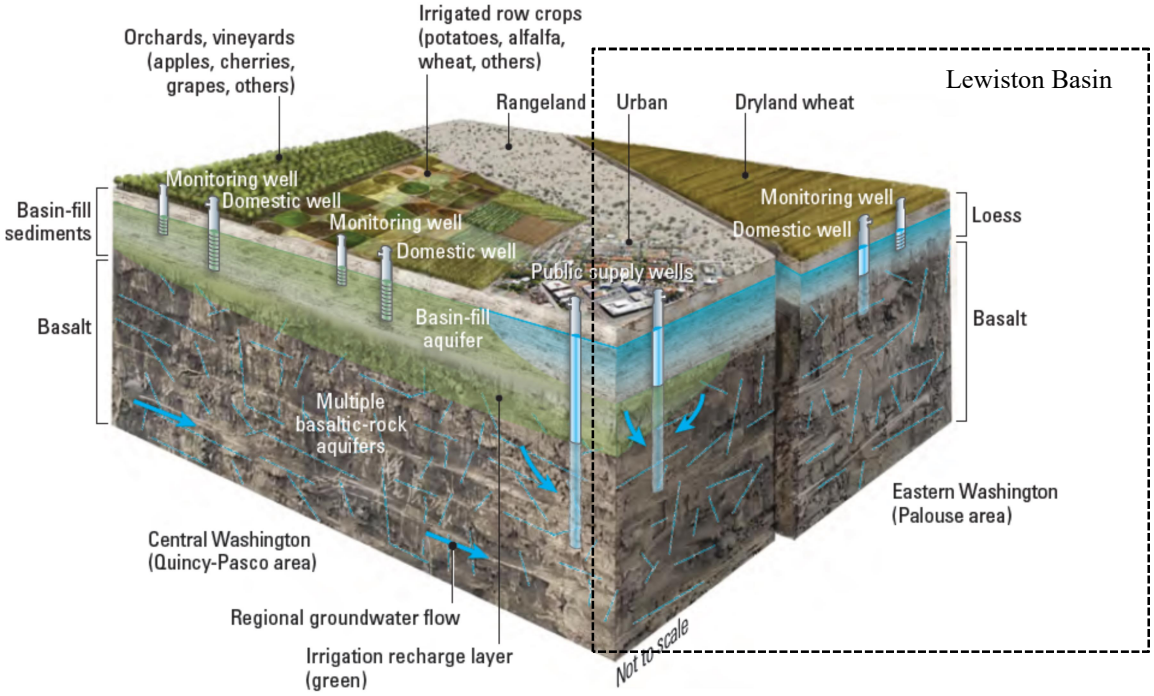

Figure 3. Block diagram of typical geologic and hydrogeologic conditions in the central Columbia Plateau (Frans et al. 2012).

4 Ground Water Nitrate Patterns

Ground Water Nitrate Summary	
Physical Patterns	• Local geology makes the Saddle Mountains and Wanapum aquifers naturally vulnerable to nitrate contamination. • Nitrate concentrations in the Saddle Mountains aquifer exceed EPA and Idaho thresholds (10 mg N/L) for protecting human health. • Nitrate concentrations appear to be lower in the deeper Wanapum and Grande Ronde aquifers, but limited data are available.
Effects	• Nitrate concentrations in the Saddle Mountains aquifer pose human health risks. • Some local residents stopped using shallow domestic wells as a drinking water source due to well nitrate contamination and health concerns. • Deep wells that draw water from below the Saddle Mountains aquifer can still become contaminated if well casing is not present to prevent mixing of water from different aquifers. • Ground water nitrate contributes to nitrate contamination in surface water (Section 5).

Ground Water Nitrate Patterns and Effects

Nitrate contamination is widespread in Lewiston Basin ground water (Figure 4). Nitrate contamination is greatest in the Saddle Mountains aquifer (0–250 feet bgs) (Figure 2 and Figure 5). The Saddle Mountains aquifer is naturally vulnerable to nitrate contamination for several reasons. It is an unconfined aquifer, meaning water seeps from the land surface through soil directly into the aquifer without any significant geologic barriers. Saddle Mountains basalt typically begins within 5–20 feet bgs, so the distance between surface nitrogen sources and the aquifer is relatively small. After water or nitrate enters the aquifer, it is mobile. Saddle Mountains basalt is composed of fractured basalt with channels and large pore spaces allowing water and pollutants can flow through easily. After entering the aquifer, pollutants can move laterally or vertically. In addition, there is limited potential for aquifer nitrate concentrations to decrease through natural processes. Some bacteria can convert nitrate to N_2 gas through denitrification; however, this process requires very low oxygen concentrations. Dissolved oxygen concentrations are fairly high in Saddle Mountains water (Figure 2), so denitrification is likely limited.

The Wanapum aquifer is also vulnerable to nitrate contamination. Water in the Saddle Mountains aquifer likely percolates downward through fractures in Saddle Mountains basalt and the Sweetwater Formation into the Wanapum aquifer (Neely 2018), transferring nitrate contamination into the Wampum. In some areas of the Lewiston Basin, Wanapum basalt is exposed along hillsides and canyon walls, so nitrate may also enter the aquifer directly through precipitation or surface runoff. Denitrification is also likely very limited in the Wanapum aquifer due to relatively high dissolved oxygen (DO) concentrations (Figure 2).

In the Saddle Mountains aquifer, nitrate concentrations are high enough to cause human health risks and have affected private well owners. Within the Lindsay Creek NPA, nitrate exceeded the concentration threshold established by EPA and Idaho to protect human health (10 mg/L) at least once in 18 of 39 (48%) ground water sites (springs and wells) drawing from the Saddle Mountains aquifer that DEQ has sampled since 2008. Some residents use wells drawing from the Saddle Mountains aquifer as a drinking water source and may be exposed to high nitrate concentrations in drinking water. Several residents told DEQ they stopped using their shallow

well as a drinking water source because nitrate concentrations were high, and they were concerned about associated health risks. Nitrate concentrations have been elevated in the Saddle Mountains aquifer since DEQ began collecting data in the 1980s (DEQ 2009). Across ground water sites with at least 5 years of data, there are no consistent nitrate concentration trend patterns (Figure 5), suggesting local effects on concentration patterns within each site.

Nitrate concentrations appear lower in wells drawing from the deeper Wanapum and Grande Ronde aquifers, but limited data are available (Figure 2). Old wells completed in these aquifers can still become contaminated because some wells completed below the Saddle Mountains do not have well casings to prevent nitrate-rich water from the shallower Saddle Mountains aquifer from entering the wells. Water drawn from such wells may be a mixture of contaminated and clean water and result in elevated nitrate concentrations. DEQ and IDWR confirmed this situation has occurred in at least one well in the Lewiston Basin. For new wells, IDWR requires installing well casings to prevent mixing of water from different aquifers.

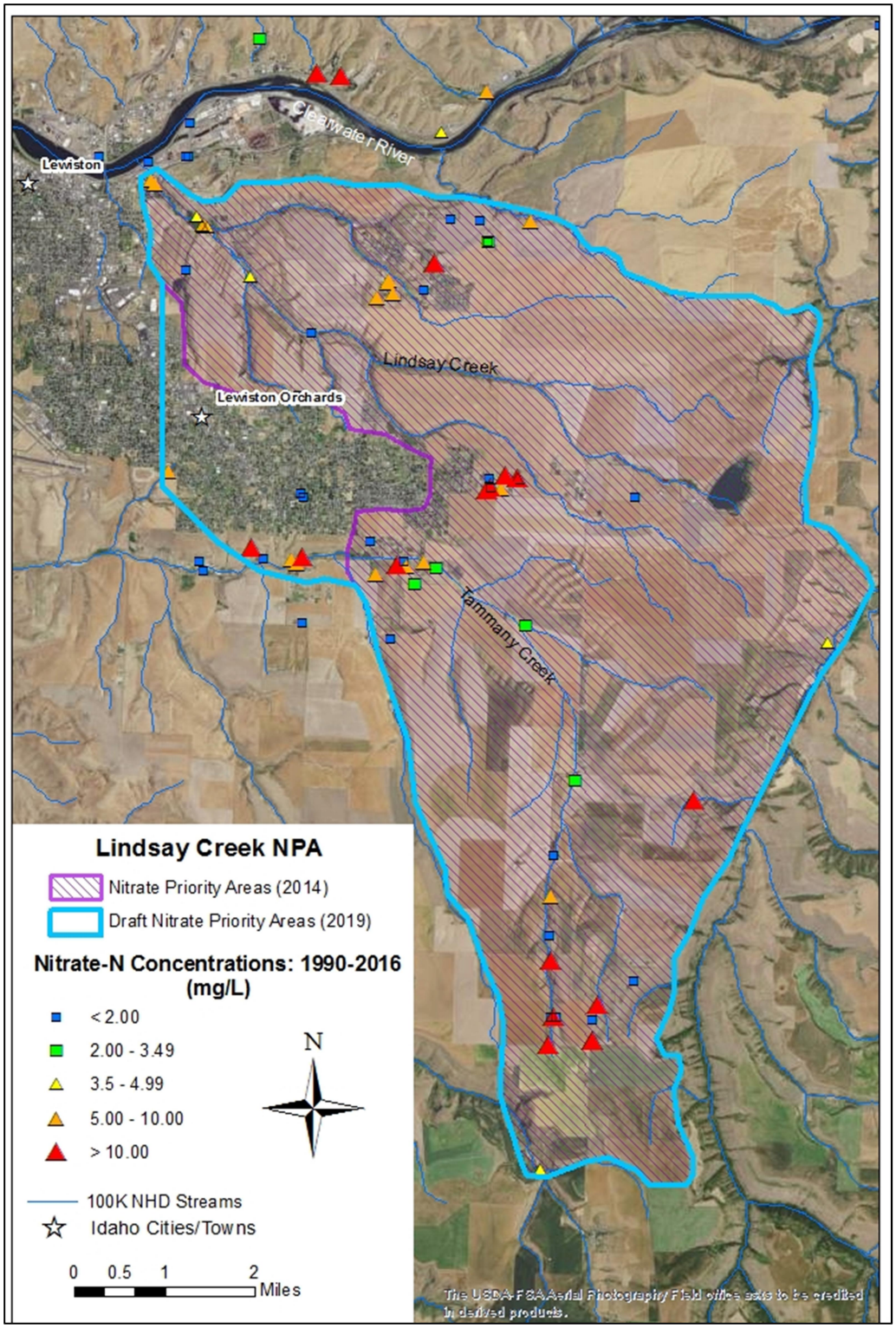

Figure 4. Ground water nitrate-N concentrations in the Lewiston Basin. Nitrate values are the most recent result for each site based on data from 1990–2016.

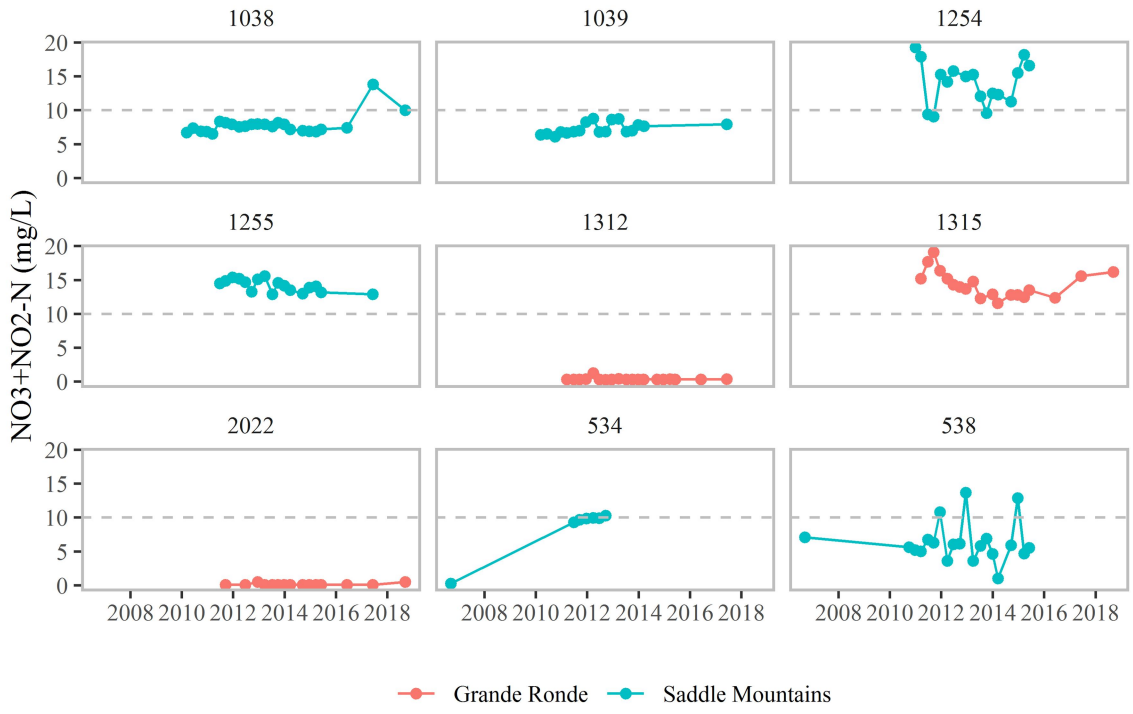

Figure 5. Nitrate trends for wells within the Lindsay Creek NPA and Lewiston Plateau GWMA with at least 5 years of data. The dashed horizontal line indicates the Idaho ground water quality standard (10 mg N/L).

5 Surface Water Nitrate Patterns

Surface Water Nitrate Summary	
Physical Patterns	• Nitrate concentrations in Lindsay and Tammany Creeks are much higher than background. • Stream nitrate concentrations are greater in wetter years. • Ground water from the Saddle Mountains aquifer appears to be a significant source of nitrate to Lindsay Creek.
Effects	• Nuisance aquatic growths reported in Lindsay and Tammany Creeks may be related to nitrate contamination. • Nitrate may adversely affect aquatic life in Lindsay Creek.

Surface Water Nitrate Physical Patterns and Effects

Nitrate concentrations in Lindsay and Tammany Creeks are much higher than background. In Lindsay Creek, measured nitrate concentrations range from 1.3–9.92 mg N/L at the mouth (Figure 6 and Figure 7) and up to 14 mg/L in some tributary segments (DEQ 2018). In Tammany Creek, measured nitrate concentrations range from 0.8–5.2 mg N/L at the mouth (Figure 8). In contrast, the upper limit for naturally occurring (background) nitrate concentrations in ground water in Idaho is 2 mg N/L (DEQ 2014), and nitrogen concentration targets typically used to protect against nuisance algal growth in streams typically range from 0.1–1.5 mg N/L (Evans-White et al. 2013).

Nitrate concentrations in Lindsay and Tammany Creeks are greater in wetter years (Figure 6 and Figure 8). In Lindsay Creek, stream nitrate concentrations at the mouth ranged from 7.93–9.92 mg N/L in water year 2018 (October 2017–September 2018), compared to 1.3–7.4 mg N/L in prior water years where chemistry data were available. During water year 2018, the Lewiston-Nez Perce County Airport recorded 15.24 inches of precipitation, compared to <10 inches most other years (Figure 6). Data are only available for 2 water years in Tammany Creek, but patterns were similar (Figure 8). In Lindsay Creek, nitrate load (pounds per day) at the mouth was also greater in wetter years and substantially greater in 2018 than in prior years where data are available (Figure 7). These patterns suggest the amount of winter precipitation strongly affects nitrate concentrations and nitrate loads during spring and summer.

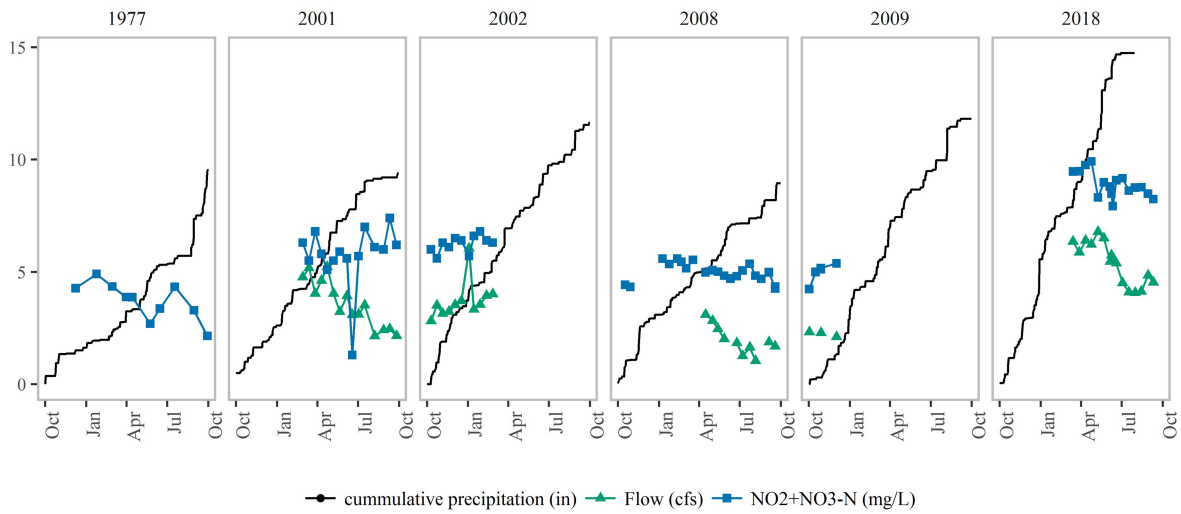

Figure 6. Water year stream flow and nitrate plus nitrite nitrogen concentrations at the Lindsay Creek mouth and cumulative precipitation measured at the Lewiston-Nez Perce County Airport.

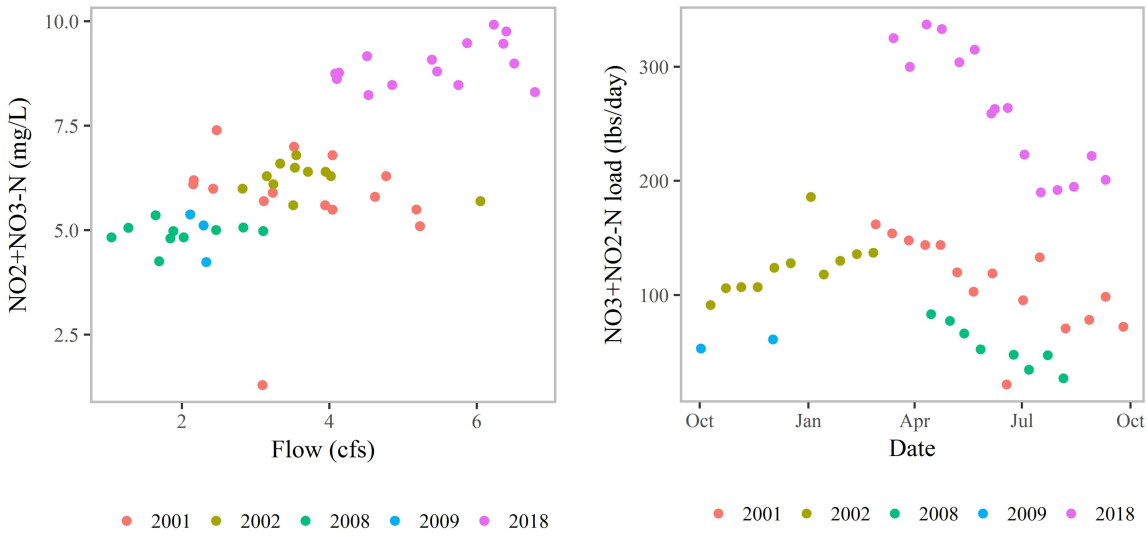

Figure 7. Flow, nitrate concentration, and nitrate load patterns at the Lindsay Creek mouth by water year.

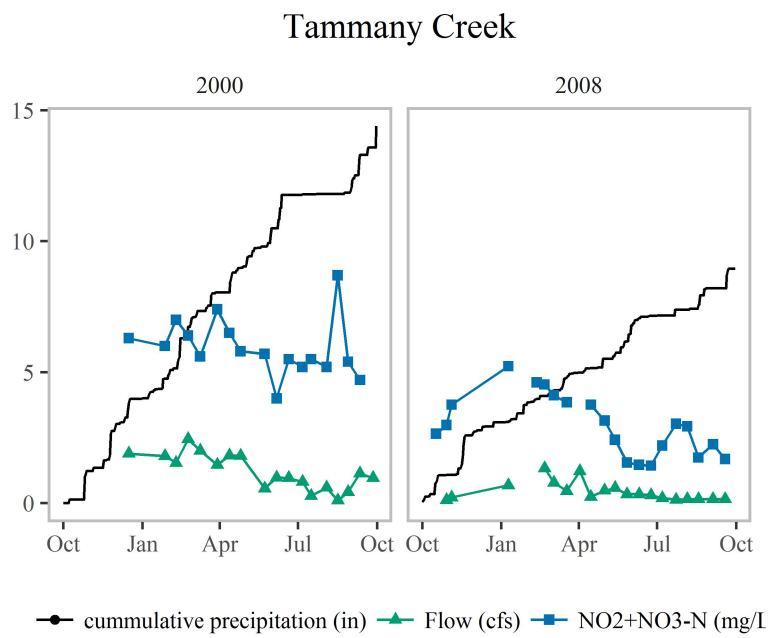

Figure 8. Water year stream flow and nitrate plus nitrite nitrogen concentrations at the Tammany Creek mouth and cumulative precipitation measured at the Lewiston-Nez Perce County Airport.

Several lines of evidence suggest ground water from the Saddle Mountains aquifer is an important source of water and nitrate to Lindsay and Tammany Creeks. First, stream flow does not have a strong seasonal pattern within water years (Figure 6 and Figure 8). Streams typically show larger spring flow peaks, greater seasonal flow variation, and have flashier flow patterns when ground water inputs are small relative to surface runoff. Second, many springs are in the Lindsay and Tammany Creek watersheds, and most are located in landslide deposits or canyon walls bisected by streams. IDWR ground water level records suggest ground water elevations in the Saddle Mountains aquifer are consistently above the elevation of many stream segments. For example, two wells within the Lindsay Creek watershed with multiple years of water level data (Wells 35N 05W 12CDA1 and 35N 05W 02CCB1) (Neely 2018) consistently had elevations greater than those in Lindsay Creek stream segments below the wells. Third, nitrate concentrations and seasonal patterns in the Saddle Mountains aquifer are similar to those in Lindsay Creek. DEQ monitored nitrate concentrations in one shallow well (16 feet deep) and one spring twice per month from March through September 2018 concurrently with nitrate monitoring at six stream sites (Figure 9). Nitrate concentrations and seasonal patterns at these sites were similar to those observed in Lindsay Creek (Figure 9). DO concentrations in Lindsay Creek also remained high (>8 mg/L) the summer 2018 and similar to those in the Saddle Mountains aquifer, despite high stream nutrient concentrations (DEQ 2018). Conductivity concentrations are also similar in the Saddle Mountains aquifer and Lindsay Creek.

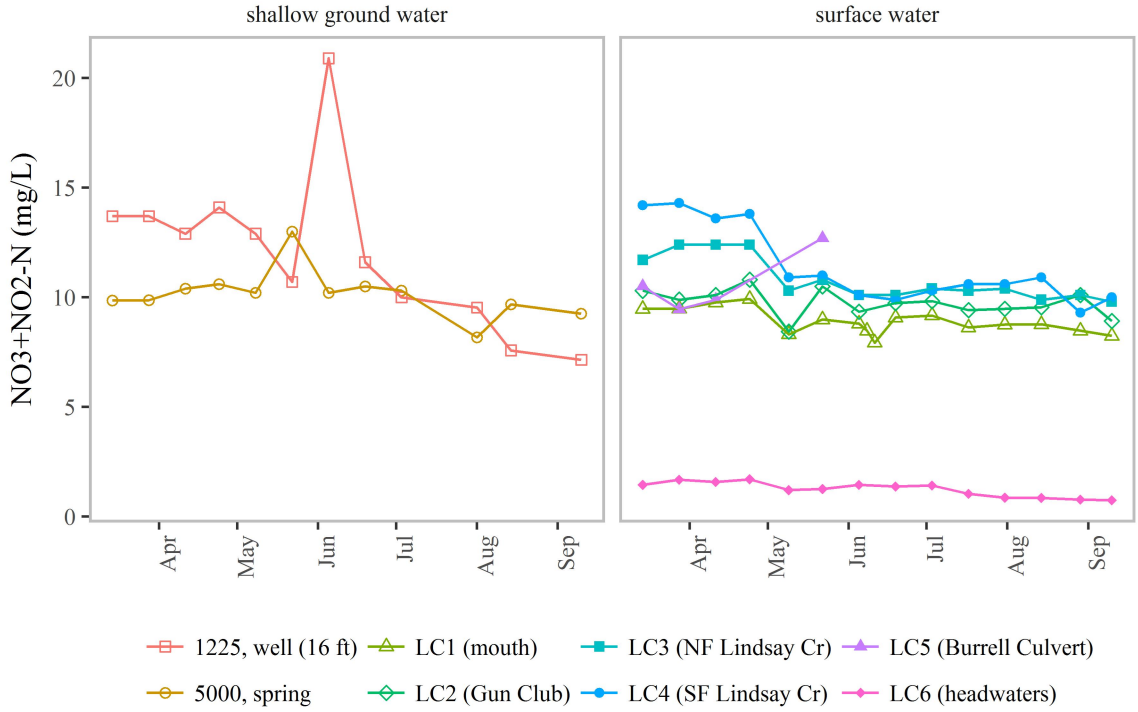

Figure 9. Nitrate plus nitrite nitrogen concentrations at surface water and shallow ground water monitoring sites within the Lindsay Creek watershed (2018).

Fourth, nitrate patterns observed in Lindsay Creek during a June 8–11, 2018, rain event suggest ground water may be significant nitrate source. DEQ measured precipitation and stream water levels, and stream chemistry at 15-minute intervals near the Lindsay Creek mouth from June 8–11, 2018, to document stream water quality patterns during a rain event. Methods are described in a monitoring report (DEQ 2018). During the rain event, stream nitrate-N and conductivity concentrations decreased as stream water levels increased. Considering both nitrate and conductivity patterns are similar in the Saddle Mountains aquifer and Lindsay Creek (Figure 8), it appears new water entering the watershed from precipitation diluted the ground water nitrate and conductivity concentration signal present before precipitation. These short-term patterns, along with interannual stream chemistry patterns described above, suggest the Saddle Mountains aquifer is a significant source of nitrate to Lindsay Creek.

The relative percent contribution of ground water to Lindsay Creek stream flow and nitrate load is not clear. Various techniques can be used to estimate the percent of stream flow that comes from baseflow (ground water). Most techniques require a stream hydrograph, a high-frequency record of stream flow, typically generated using high frequency (15–30 minute) water-level values recorded with a pressure transducer and an equation estimating flow based on water level (a rating curve). In 2018, DEQ installed a pressure transducer to record stream water level at 15-minute intervals near the Lindsay Creek mouth (DEQ 2018). However, DEQ could not develop a reliable rating curve for Lindsay Creek due to periodic sensor malfunctions and changes to downstream water level control structures during the study period (DEQ 2018). Baseflow separation techniques could potentially be used to estimate the contribution of ground water to

flow and nitrate load in Lindsay Creek, but the necessary hydrograph data are not currently available.

Combined with elevated stream phosphorus and temperature, nitrate concentrations in Lindsay and Tammany Creeks may contribute to nuisance aquatic growth and other effects on aquatic life. In 1976–1977, DEQ observed "brown, filamentous slime growths…formed in response to high organic and nutrient concentrations" at the mouth of Lindsay Creek (IDHW 1978). DEQ also observed brief localized instances of extensive algal growth in Lindsay Creek in 2018. In Tammany Creek, DEQ observed DO concentrations less than required by Idaho's water quality standards (6 mg/L) for controlling nuisance aquatic growth and protecting aquatic life (DEQ 2010). Elevated nutrient concentrations and temperatures promote growth of aquatic bacteria, plant communities, and chemical reactions that consume DO and stress many aquatic organisms.

6 Potential Nitrate Sources

Potential Nitrate Sources Summary

- Potential nitrate sources in the basin include wildlife, soil organic matter, fertilizers, livestock, stormwater discharges, and septic systems.
- Septic effluent is one confirmed nitrate source. It is present in Lindsay Creek and the Saddle Mountains aquifer, including in some domestic wells.
- Nitrogen stable isotope data suggest multiple sources may contribute to ground water contamination.
- Fertilizers are likely a significant nitrate source.
- The relative contribution of different nonpoint sources to nitrate contamination is not clear.
- Nitrate sources and their relative importance likely differ between the Lindsay and Tammany Creek watersheds.

There are many potential nitrate sources in the Lewiston Basin. The Lindsay and Tammany Creek TMDLs attributed all nitrate contamination to nonpoint sources. No point sources permitted under the National Pollution Discharge Elimination System (NPDES) or Idaho Pollution Discharge Elimination System exist within the basin (excluding construction general permits). However, the City of Lewiston and Lewis Clark State College stormwater systems discharge to Lindsay and Tammany Creeks, and EPA developed a draft NPDES stormwater discharge permit that goes into effect in 2019 (EPA 2018). Potential nitrate sources in the basin include wildlife, soil organic matter, fertilizers, livestock, stormwater discharges, and septic systems. Identifying nonpoint nitrate sources to ground water and their relative importance is critical; nitrate in ground water has contaminated domestic wells drawing from the Saddle Mountains aquifer and contributed to nitrate contamination in Tammany and Lindsay Creeks.

In 2018, DEQ confirmed septic systems are one nitrate source to both ground water and surface water in the Lindsay Creek watershed. Approximately 800 parcels in the watershed (~15% of parcels) have septic systems. DEQ tested for two artificial sweeteners and caffeine in ground water, surface water, and one septic system within the Lindsay Creek watershed. Artificial sweeteners and caffeine are widely used as markers of human wastewater. Results demonstrated septic effluent is present in the Saddle Mountains aquifer, including some domestic wells, and in Lindsay Creek (DEQ 2019). Nitrate concentrations were high (7–10 mg N/L) where septic indicator chemicals were detected and much lower (<1.1 mg N/L) where they were not,

suggesting septic effluent is one source of nitrate to ground water and Lindsay Creek. Results are described in detail in a separate report (DEQ 2019).

Nitrogen stable isotope data suggest nitrogen in ground water may also come from additional sources. Through Lindsay Creek NPA monitoring, DEQ measured the ratio of naturally-occurring nitrogen stable isotopes ($^{15}N/^{14}N = \delta^{15}N$, units = $^{0}/_{00}$) of total nitrogen in ground water samples from 15 ground water sites. Some nitrogen sources have distinct $\delta^{15}N$ values so comparing $\delta^{15}N$ in ground water samples to typical $\delta^{15}N$ values of different sources can identify potential nitrogen sources. Figure 10 shows $\delta^{15}N$ values observed at ground water sites (circles) and $\delta^{15}N$ ranges reported in the literature (lines) for different nitrogen sources (Xue et al. 2009). The $\delta^{15}N$ of some sources overlap, and when nitrogen undergoes chemical and biological (nitrification and denitrification) processes, $\delta^{15}N$ values change through fractionation (Xue et al. 2009; Nikolenko et al. 2017). Nitrogen stable isotopes therefore cannot always clearly identify nitrogen sources. In the Lewiston Basin, available data do not clearly identify sources for all sites. Nitrogen at ground water sites with $\delta^{15}N$ near $10^{0}/_{00}$ likely comes from human or animal waste. Nitrogen sampled one site had a relatively low value ($1.68^{0}/_{00}$) within the typical range of inorganic fertilizers, suggesting a fertilizer source (Figure 10). However, sources for most sampled sites are not clear because of overlapping source $\delta^{15}N$ ranges, and because nitrogen in ground water may come from a mixture of sources.

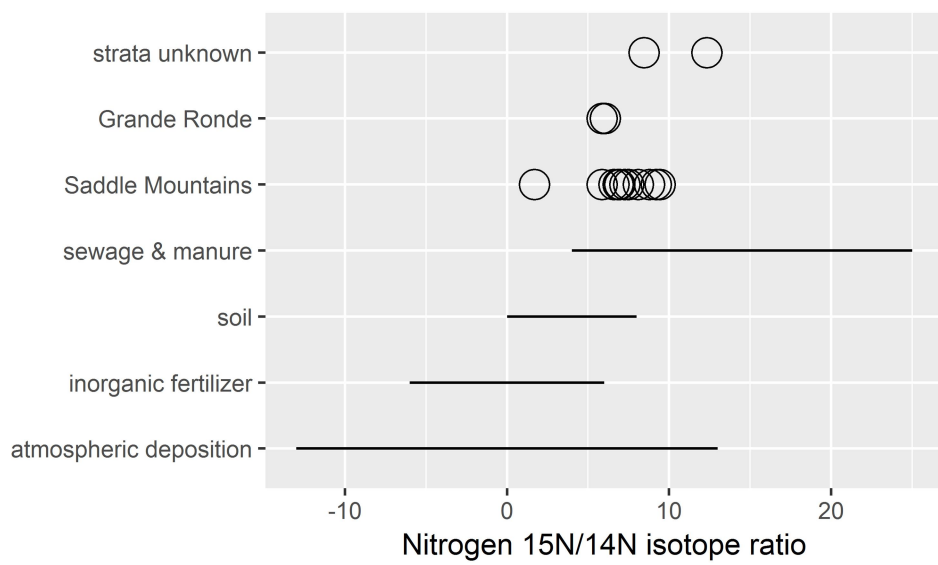

Figure 10. Nitrogen stable isotope ratios reported in the literature (reviewed by Xue et al. (2009)) for sources (lines) and at ground water sites within the Lewiston Basin.

Agriculture may be a significant nitrate source within the Lewiston Basin. Regionally, the percentage of land area used as cropland is the primary factor influencing nitrate concentrations within basalt aquifers of the Columbia Plateau (Frans et al. 2012). Nitrogen fertilizer applied to cropland may be a significant nitrate source to the Saddle Mountains aquifer and surface water. In a 2002 Lindsay Creek farming practices survey, growers reported applying fertilizer to fields at 75–100 pounds per acre for winter wheat and 60–100 pounds per acre for spring wheat (NPSWCD 2002). Seventy-two percent of land area within the Lindsay Creek watershed and 65% of land area within the Tammany Creek watershed is used for dryland agriculture (USGS

2018). Dominant crops in both watersheds include winter and spring wheat and legumes. In addition, DEQ identified livestock as one source of Lindsay Creek surface water *Escherichia coli* (*E. coli*) contamination (DEQ 2016). Livestock therefore are also a potential source of surface water nitrate contamination.

The relative percent contribution of different nonpoint nitrate sources to nitrate contamination is not clear and merits further investigation. The contamination sources and their relative importance likely differ between the Lindsay and Tammany Creek watersheds. The Lindsay Creek watershed sits on an island of Saddle Mountains basalt (Figure 11), and little or no hydrologic communication occurs between Saddle Mountains basalt within the two watersheds (Daniel Sturgis, IDWR, personal communication, March 11, 2019). The nitrate sources, their relative importance, and actions needed to reduce contamination in the Saddle Mountains aquifer therefore likely differs between the two watersheds.

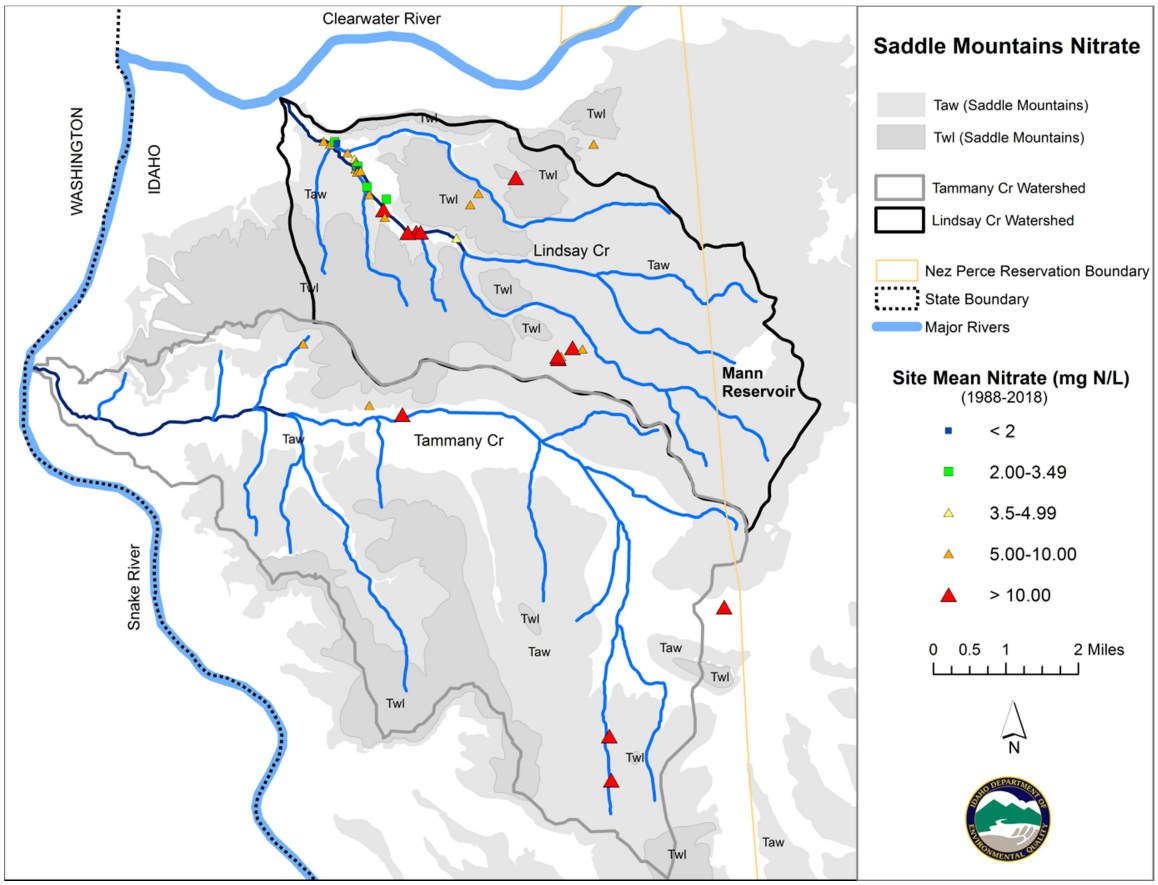

Figure 11. Locations Asotin member basalt (Taw) and Lewiston Orchards basalt (Twl) within the Saddle Mountains aquifer and ground water sites (springs and wells) drawing from Saddle Mountains aquifer.

7 Nitrate Management Efforts

Nitrate Management Summary

- DEQ developed TMDLs for Lindsay and Tammany Creeks specifying maximum pollutant input sources that can occur while still meeting state water quality standards.
- Idaho Code §39-3612 requires to TMDLs to "be used by all designated management agencies for achieving water quality standards."
- To address nonpoint pollution from agriculture, designated management agencies work with landowners to identify and adopt agricultural BMPs on a voluntary basis. Per Idaho Code §39-3611(10), adoption of agricultural BMPs must be voluntary.
- DEQ established the Lindsay Creek NPA in 2008 and monitors ground water nitrate within the NPA annually.
- A ground water management plan for the Lindsay Creek NPA was drafted in 2009 but was never finalized.
- In 2018, the City of Lewiston installed a sewer line in the eastern Lewiston Orchards to reduce nitrate inputs from septic systems.
- In 2019, DEQ will conduct a periodic review of the Lindsay Creek TMDL required by state law and will hold public meetings to solicit public input on nitrate management.
- IDWR and DEQ are working with the Lewiston Plateau GWMA Citizens Advisory Committee to develop an aquifer atlas to educate the public about local hydrogeology.
- DEQ developed a timeline of water quality monitoring and management efforts (Appendix A).

Nitrate contamination in the Lewiston Basin and efforts to address it date back many years. In 1978, the Idaho Department of Health and Welfare Division of Environmental Quality identified elevated nutrient concentrations in Lindsay Creek and observed associated nuisance algal growth (IDHW 1978). DEQ first documented elevated ground water nitrate concentrations in the area in the 1980s (DEQ 2009). DEQ is mandated by the federal Clean Water Act and Idaho statutes and rules to address nitrate contamination.

Federal Clean Water Act and Surface Water

The federal Clean Water Act requires states to identify waters that do not meet state water quality standards for protecting aquatic life and human uses (i.e., recreation) of water. For waters that do not meet state water quality standards, states must also develop a water quality improvement plan (i.e., TMDL). A TMDL specifies maximum inputs of a pollutant from all sources that can occur while still meeting state water quality standards and are reviewed and approved by EPA. DEQ identified Lindsay and Tammany Creeks as impaired by nitrate and developed nitrate TMDLs for Lindsay Creek (DEQ 2007) and Tammany Creek (DEQ 2010). In both watersheds, DEQ attributed all pollutant loading to nonpoint sources and identified ground water as a significant source of nitrate to surface water.

After a TMDL is developed, Idaho Code §39-3612 requires TMDLs to "be used by all designated management agencies for achieving water quality standards." Designated management agencies are the Idaho Department of Lands for timber harvest, oil and gas, and mining activities; ISWCC for grazing and agricultural activities; Idaho Transportation Department for public roads; Idaho Department of Agriculture for aquaculture; and DEQ for all other activities (Idaho Code §39-3602(9)). After the TMDLs were developed, designated management agencies and other stakeholders attempted to reduce nitrate inputs from agricultural nonpoint sources and from septic systems.

To address nonpoint pollution from agriculture, designated management agencies worked with landowners to identify and adopt agricultural BMPs on a voluntary basis. Idaho Code §39-3611(10) requires that BMPs for agricultural nonpoint source activities must be implemented on a voluntary basis. The ISWCC developed the *Lindsay Creek Watershed Total Maximum Daily Load Implementation Plan for Agriculture* (ISWCC 2008), which identified agricultural BMPs landowners could use to reduce agricultural nonpoint source pollution. Since 2008, DEQ used federal Clean Water Act §319 nonpoint source management program grant funds provided by EPA to fund two projects in Lindsay Creek ($493,534 total) and one project in Tammany Creek ($185,247) addressing agricultural nonpoint source pollution.

The City of Lewiston acted to address nitrate contamination from septic systems. In 2018, the city installed a sewer trunk line to extend sewer service into the eastern Lewiston Orchards and cited elevated nitrate as one justification for the extension project (City of Lewiston URA 2017).

Idaho Ground Water Quality Rule

DEQ is mandated to address nitrate contamination by Idaho's Ground Water Quality Rule. The rule states DEQ "is designated as the primary agency to coordinate and administer ground water quality protection programs for the state" (IDAPA 58.01.11.001.02). Regarding ground water contamination, the rule states the following:

> The discovery of any contamination exceeding a ground water standard that poses a threat to existing or projected future beneficial uses of ground water shall require appropriate actions, as determined by the Department, to prevent further contamination. These actions may consist of investigation and evaluation, or enforcement actions if necessary to stop further contamination or clean up existing contamination, as required under the Environmental Protection and Health Act, Section 39-108, Idaho Code (IDAPA 58.01.11.400.03)

In the Lewiston Basin, nitrate concentrations exceed Idaho's ground water quality standard for nitrate (10 mg N/L) and one existing beneficial use of ground water (domestic water supply) is impaired by nitrate contamination; some residents reported they stopped using private wells as a drinking water source due to nitrate contamination and the associated health concerns.

Idaho's Ground Water Quality Rule states the following:

> The beneficial uses of interconnected surface water shall be recognized when evaluating ground water quality protection. The implementation of water quality programs shall ensure that the quality of ground water that discharges to surface water does not impair the identified beneficial uses of surface water and that surface water infiltration does not impair beneficial uses of ground water. (IDAPA 58.01.11.15.03)

The Lindsay Creek (DEQ 2007) and Tammany Creek (DEQ 2010) TMDLs identified ground water as a source of nitrate contamination to surface water and determined nitrate impairs beneficial uses of surface water and these creeks. Nitrate concentrations in some springs monitored by DEQ exceed nitrate target concentrations developed in the stream TMDLs to protect beneficial uses of surface water (DEQ 2018; DEQ 2009). Ground water discharges to surface water in the Lewiston Basin and likely contributes to surface water beneficial use impairment.

DEQ has taken several actions to address ground water nitrate contamination. In 2008, DEQ designated the Lindsay Creek NPA (DEQ 2008; DEQ 2014) (Figure 1). NPAs have degraded

ground water quality due to nitrate contamination and are areas where additional investigation, evaluation, protection, and improvement efforts should be focused (DEQ 2014). Since 2008, DEQ has monitored ground water nitrate in the Lewiston Basin each year. DEQ collects data from privately owned wells and springs where property owners allow access and DEQ sampling. DEQ periodically updates NPA boundaries based on monitoring data collected by DEQ and other agencies. Lindsay Creek NPA boundaries were updated in 2014 (DEQ 2014), and DEQ anticipates revising the Lindsay Creek NPA boundary again in 2019 based on 1990–2016 monitoring data (Figure 4). The 2014 NPA delineation and ranking process ranked the Lindsay Creek NPA as third on the state-wide NPA priority list; rankings are used to prioritize implementing protective management strategies or corrective action measures (DEQ 2014).

In 2009, DEQ and the Lindsay Creek WAG developed the *Lindsay Creek Nitrate Priority Area Ground Water Quality Management Plan (Draft)* (DEQ 2009), but the plan was never finalized. It recommended more public education about nitrate health risks and sources, and voluntary implementation of agricultural and residential BMPs to reduce nitrate inputs to ground water.

In 2019, DEQ will review the Lindsay Creek TMDL. Idaho Code (§39-3611(7)) requires DEQ to review TMDLs every 5 years to evaluate if assumptions, analyses, targets, and loads developed in TMDLs are still appropriate. During this process, DEQ must convene a watershed advisory group (WAG) composed of local interests affected by water quality management. Through the Lindsay Creek TMDL review process and associated public meetings, DEQ will seek input from the Lindsay Creek WAG, Lewiston Plateau GWMA Citizens Advisory Committee, local government entities, watershed residents, and other stakeholders on appropriate actions for addressing nitrate contamination. This document summarizes information available to stakeholders involved in the review process.

8 Information Gaps Relevant to Nitrate Management

Information about nitrate sources, fate, and transport processes may help identify and prioritize pollutant reduction efforts. DEQ identified the following information gaps relevant to nitrate management.

- **Inventory of wells drawing from the Saddle Mountains aquifer within the Lewiston Basin.** Residents using such wells for drinking water may have increased health risks due to nitrate contamination. These residents are a target population for education about nitrate health risks and ground water nitrate monitoring efforts. Inventorying these wells would require reviewing well logs (where available) and identifying the aquifer each well draws from. A complete inventory may not be possible because not all wells have well logs.
- **Extent of nitrate contamination in the Wanapum and Grande Ronde aquifers.** Additional data from these deeper aquifers are needed to confirm if nitrate contamination is only prevalent in the Saddle Mountains aquifer.
- **Direction and rate of ground water flow.** Documenting or mapping the ground water direction and flow, especially in the Saddle Mountains aquifer, would be used in combination with nitrate concentration data to identify aquifer recharge areas, potential nitrate sources, nitrate contamination hotspots, and fate of nitrate in ground water.

- **Saddle Mountains aquifer ground water residence time**. The amount of time ground water spends in the Saddle Mountains aquifer before exiting as surface water (through a spring or stream) or entering the Wanapum aquifer will affect how quickly land use changes will translate into reduced nitrate concentrations.
- **Location and extent of hydrologic communication between the Saddle Mountains and Wanapum aquifers.** The Wanapum aquifer is likely at least partly recharged by water percolating downward through fractures in the Saddle Mountains aquifer (Neeley 2018). Identifying areas where this occurs may help focus efforts to protect the Wanapum aquifer from nitrate contamination.
- **Relationship between water table levels and ground water nitrate in the Saddle Mountains aquifer**. If ground water patterns are similar to those in surface water, and ground water nitrate concentrations are greater in wetter years, it may be possible to use winter precipitation amounts to anticipate water years where elevated nitrate in domestic wells will be prevalent. DEQ could warn residents in advance that particularly high nitrate concentrations are anticipated. Ground water nitrate data would need to be collected quarterly in Saddle Mountains wells where IDWR has installed pressure transducers to monitor ground water levels to determine if a relationship exists between water level and ground water nitrate concentrations.
- **Relative percent contribution of different nonpoint nitrate sources to the Saddle Mountains and Wanapum aquifers.** Identifying the relative contribution of different nonpoint nitrate sources would help stakeholders focus limited resources available for addressing ground water nitrate contamination. Watershed modeling would likely be needed to estimate the relative contribution of different sources.
- **Stream hydrograph for Lindsay and Tammany Creeks.** Estimating the percent contribution of ground water to stream flow or the percent contribution of different nonpoint nitrate sources to nitrate contamination would require a hydrograph and multiple years of stream flow data. Baseflow separation techniques can be applied to a hydrograph to estimate the percent contribution of ground water to stream flow. Watershed modeling efforts to estimate the relative contribution of different sources would also require a hydrograph and multiple years of continuous stream flow data.
- **Inventory and map of Saddle Mountains aquifer discharge areas.** Ground water from the Saddle Mountains aquifer may discharge to surface water through springs, seeps, and gaining stream segments. Identifying and mapping discharge sites may help assess ground water inputs to surface water and identify potential monitoring locations.
- **Relative percent contribution of each tributary to nitrate load at the Lindsay Creek mouth and Tammany Creek mouth.** Identifying the relative contribution of each tributary would prioritize efforts to reduce nitrogen inputs to ground water and surface water.
- **Threshold nutrient concentrations (nitrogen and phosphorus) that stimulate nuisance algal growth in Lindsay and Tammany Creeks.** The relationship between nutrient concentrations and nuisance algal growth is often complex and site-specific. Determining ecologically-based thresholds specific to the Lewiston Basin would then identify protective surface water target concentrations to work towards.

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Appendix A. Lewiston Basin Water Quality Timeline

Time Period	Milestone
Before 1970	**1907:** The Bureau of Reclamation constructs Mann Reservoir. The reservoir is filled by the Sweetwater Canal, which carries water from Sweetwater and Webb Creeks (Figure 1).
1970s	**1975**: US Army Corps of Engineers completes construction of the Clearwater Levee, creating a physical barrier that prevents fish from entering Lindsay Creek from the Clearwater River. **1976–1977**: DEQ monitored NO_3-N and other parameters in surface water at the Lindsay Creek mouth (IDHW 1978). DEQ concluded water quality was impaired by nutrients and bacteria.
1980s	**1987**: The Asotin County Public Utility District submitted a petition to EPA requesting the Russell aquifer, which includes the Lindsay Creek watershed, be designated as a sole source aquifer. The Russell aquifer was defined as the upper 800 feet of the Grand Ronde Formation within the Lewiston Basin. **1988**: DEQ placed Lindsay Creek on Idaho's 1988 §303(d) list as PNRS # 1141. **1988**: DEQ sampled NO_2+NO_3-N in 29 domestic wells across the Lindsay and Tammany Creek watersheds. Results are found in the *Lindsay Creek Nitrate Priority Area Ground Water Management Plan (Draft)* (DEQ 2009). **1988**: EPA designated the Lewiston Basin aquifer (previously called the Russell aquifer) as a sole source aquifer under the Safe Drinking Water Act §1424(e).
1990s	**1992:** IDWR designated the Lindsay Creek GWMA, which included a portion of the Lindsay and Tammany Creek watersheds. The GWMA was designated due to concerns over decreasing water levels in wells completed in shallow aquifers (IDWR 2015). **1997**: DEQ sampled NO_2+NO_3-N and pesticides in four domestic wells within the Lindsay Creek watershed as part of a study evaluating ground water quality in the Russell sole source aquifer. DEQ concluded NO_2+NO_3-N concentrations in residential wells within the Lindsay Creek watershed were elevated and were a concern (DEQ 1997).
2000–2010	**2001:** Tammany Creek sediment TMDL developed and approved by EPA (DEQ 2001). **2001–2002**: IASCD monitored surface water NO_2+NO_3-N and other parameters at six locations in the Lindsay Creek watershed (IASCD 2002). DEQ subsequently used these data to develop the Lindsay Creek TMDL. **2001–2004**: NPSWCD monitored temperature at the Lindsay Creek mouth in 2000, 2001, 2003, and 2004 (NPSWCD 2013). **2005**: DEQ collected surface water NO_2+NO_3-N, cation and anion, *E. coli,* DO, temperature, caffeine, surfactant (MBAS), and nitrogen isotope samples. Monitoring results are described in the Lindsay Creek TMDL (DEQ 2007). **2005**: NPSWCD monitored temperature at the Lindsay Creek mouth (NPSWCD 2013). **2005**: DEQ used isotopes to evaluate the age of water in selected municipal drinking water wells within the Lewiston Basin (DEQ 2005). **2007**: EPA approved the Lindsay Creek TMDL. The TMDL established target concentrations, load capacities and load allocations for nutrients (NO_2+NO_3-N), *E. coli*, and total suspended solids (sediment). **2007**: DEQ awarded Palouse Clearwater Environmental Institute a Clean Water Act §319 grant for riparian and animal management projects in the Lindsay Creek watershed. **2007–2008**: DEQ monitored surface water NO_2+NO_3-N at several locations in the Lindsay and Tammany Creek watersheds. Results are documented in this report (Section 5, Figure 6). **2008**: DEQ designates the Lindsay Creek NPA and begins annual ground water nitrate monitoring (DEQ 2008). **2008**: ISWCC and NPSWCD develop the *Lindsay Creek Watershed TMDL Implementation Plan for Agriculture* (NPSWCD 2008). **2009**: A draft *Lindsay Creek Nitrate Priority Area Ground Water Quality Management Plan* is developed but not finalized (DEQ 2009). **2009–2010**: NPSWCD monitored temperature at the Lindsay Creek mouth (NPSWCD 2013). **2010**: Tammany Creek nutrient and *E. coli* TMDLs developed and approved by EPA (DEQ 2010).

Time Period	Milestone
2011–present	**2012:** DEQ awarded NPSWCD a Clean Water Act §319 grant to address Lindsay Creek. Activities included stream and road inventories, monitoring, and land treatments to address nutrients, sediment, and *E. coli* (NPSWCD 2016). **2012–2013**: DEQ monitored *E. coli* in Lindsay Creek in response to a complaint. Results indicated elevated *E. coli* concentrations resulted from human and ruminant *E. coli* sources (DEQ 2016). Idaho North Central Public Health District and DEQ performed follow-up actions with owners of potential source properties. **2013:** IDWR rescinded the Lindsay Creek GWMA and designated the Lewiston Plateau GWMA, which includes the entire Lindsay Creek watershed and additional portions of the Lewiston Basin (IDWR 2015). **2014**: DEQ revised boundaries of the Lindsay Creek NPA based on recent ground water monitoring data (DEQ 2014). **2017**: DEQ monitored nutrients, temperature, pH, and several potential septic system indicators in outflow of a culvert draining the eastern Lewiston Orchards twice in spring 2017. NO_2+NO_3-N concentrations were very high, but results from septic indicators were inconclusive (DEQ 2017). **2017**: The Bureau of Reclamation publishes the final environmental impact statement for the Lewiston Orchards Water Transfer Project (BOR 2017). **2018**: DEQ collected surface and ground water data for the Lindsay Creek TMDL review March–September 2018 (DEQ 2018). **2018**: DEQ documented the presence and spatial distribution of septic effluent in ground water and surface water within the Lindsay Creek watershed using artificial sweeteners and caffeine (DEQ 2019). **2019**: DEQ forms Hatwai/Lindsay WAG to seek advice on water quality management in Hatwai and Lindsay Creeks **2019**: DEQ revises Lindsay Creek NPA boundaries based on 1990–2016 monitoring data.