3.0 SOURCE ASSESSMENT

The source assessment phase of TMDL development identifies all known sources of nutrients that may contribute to both elevated nutrient concentrations and the stimulation of algal growth in the Rio Hondo. The source assessment also determines nutrient inputs, measured as loads that will consider magnitude and support the formulation of the load allocation and wasteload allocation of the TMDLs (USEPA, 1999). Where available data are incomplete or where the level of uncertainty in the characterization of sources is large, the recommended approach to TMDL assignments requires the development of allocations based on estimates utilizing the best available information.

SWQB fieldwork includes an assessment of the potential sources of impairment. The completed Pollutant Source(s) Documentation Protocol form in Appendix D provides documentation of a visual analysis of probable sources along the assessed reach. Although this procedure is subjective, SWQB feels that it provides the best available information for the identification of potential sources of impairment in this watershed. The following load estimates are determined using the best available methods that were known at the time of calculation and may be revised in the future. Potential nutrient sources in the upper Rio Hondo watershed are:

- Municipal wastewater treatment plant
- Construction sites and urban development
- Recreational Activities
  - Ski slope runoff
  - Hiking and mountain biking trail system
  - Parking lots (impervious areas)
- Residential areas
  - Landscape maintenance
  - Septic tank- leach field disposal systems
  - Backyard livestock/pets
- Atmospheric deposition
- Undeveloped land (background/natural conditions)

Construction and urban development contribute nutrients by disturbing the land and consequently increasing soil erosion, and by increasing the impervious area within the watershed. Recreational activities such as hiking, biking, and skiing can also contribute nutrients to the stream by reducing plant cover and increasing soil erosion (e.g. trail network), direct application of human waste, campfires and/or wildfires, and dumping trash near the riparian corridor. Residential areas contribute nutrients from septic tank disposal systems, landscape maintenance, and/or backyard livestock (e.g. horses) and pet wastes. Atmospheric deposition adds nutrients directly to the waterbody through dryfall and rainfall. Undeveloped land delivers nutrients from decaying plant material, soil erosion, air deposition, and wild animal waste. The contributions from undeveloped land are small and generally considered to represent background, or natural levels.

Nutrients from these sources reach the Rio Hondo primarily by two routes: directly in overland flow (stormwater runoff and spring snowmelt) and indirectly in ground water. Nutrients applied

directly to land (e.g. fertilizers, pet wastes) can be carried overland in storm water runoff or can dissolve and percolate through the soil to reach ground water. Septic tank disposal systems contribute nutrients primarily into ground water, which may eventually discharge into the stream.

It is important to consider not only the land directly adjacent to the stream, which is predominantly privately held, but also to consider upland and upstream areas in a more holistic watershed approach to implementing this TMDL. Analyses presented in these TMDLs demonstrate that defined loading capacities will ensure attainment of New Mexico water quality standards.

Nutrient Export Coefficients

Nutrient export coefficients are the amounts of nitrogen or phosphorus exported from an area over a specific time period and are generally applied to a specific land use. They are typically expressed as grams of phosphorus per square meter per year, or pounds of nitrogen per acre per month, or some other mass-area-time unit.

The simplifying assumptions regarding nutrient transport and cycling limit the export coefficient approach because diverse physical, biological, and chemical processes are lumped into one parameter, an average nutrient generation rate. Another limitation is that export coefficients for this study are based on literature values, not on site-specific data. This approach yields an estimate of total nutrient loads to surface waters in the watershed, but does not estimate loading at any particular point in the watershed. Despite these limitations, the use of export coefficients to estimate nutrient loads is the best available method given the minimal data requirements and given that detailed watershed models have not been developed for the upper Rio Hondo watershed. The results will provide a rough approximation of the loading to the upper Rio Hondo watershed and will indicate the general sources of that loading. Future applications of the nutrient export methods will be enhanced by more intensive surface water surveys that collect and analyze actual nutrient export data from the region as well as by more recent and detailed land use/land cover data.

Numerous studies have derived land use based loading coefficients characteristic of various watershed conditions for estimating nonpoint source pollutant yields (e.g. Reckhow, et al., 1980; Rast and Lee, 1983; Frink, 1991; McFarland and Hauck, 2001). Nutrient loads from both runoff and ground water have been evaluated for all of the identified nutrient sources in the Rio Hondo. Surface runoff pollutant loads from various land uses were calculated by applying appropriate nutrient export coefficients from published literature to the corresponding land use areas.

Nutrient export coefficients for this study were obtained from literature values since no site-specific values existed for the Rio Hondo. Efforts were made to select export coefficients that most appropriately represented the land use types within the upper Rio Hondo watershed, and that best represented the environmental conditions in Northern New Mexico. Best professional estimates of probable values for nutrient export coefficients were determined for each pollutant using a hierarchical approach. First, coefficients from a variety of studies and publications were accumulated. From these, values from western states were selected. In the absence of western data, median national values from various sources were selected.

Natural or undeveloped lands contribute surface water loads through natural processes (e.g., leaf litter decay or soil erosion). Background loads were estimated using reference water quality concentration data and streamflow data from water quality stations located above the WWTP. Ground water loads were estimated using per capita septic disposal system nutrient load calculations. Air deposition load was calculated using a literature value deposition rate, which accounts for the amount of nutrients that deposit on the surface of the water. These source-specific load estimates account for the differences in magnitudes between sources and provide a basis for allocating loads.

There will be situations where the annual export coefficient is not appropriate, such as for waterbodies with short (a few weeks to a few months) hydraulic residence times. Under these conditions, seasonal export coefficients should be used, where attention is given to the sources of those nutrients that are responsible for excessive algal growth that impairs the waterbody's water quality and impedes the designated uses of the watershed.

3.1 Total Phosphorus

3.1.1 Surface Water Loads

Land use and natural sources were identified as potential sources of phosphorus to the Rio Hondo. This section provides discussion and estimates of the surface water loads from each of these sources.

Land Uses

The upper Rio Hondo watershed has four main land uses that were identified as potential sources of phosphorus (Table 3-1, Figure 1-1): built-up (urban), forest, shrubland, and grasslands. Nutrients generally reach the Rio Hondo from land uses that are in close proximity to the stream because the hydrological pathways are shorter and have fewer obstacles than land uses located away from the riparian corridor. However, during spring snowmelt and in storm water runoff, those distant land uses can become hydrologically connected to the stream, transporting nutrients from the hillslopes to the stream during these time periods.

For this analysis, the Export Coefficient Model (Reckhow, et al., 1980) was modified to generate phosphorus loads from specific land uses by incorporating a distance-decay component in the export coefficient similar to the methods used by Johnes and Heathwaite (1997) and Endreny and Wood (2003). Phosphorus export weighting was based on distance from the stream with 50 m, 500 m, and 5000 m buffer zones. The largest unit-area load was assigned to the 50 m buffer zone and the smallest unit-area load was assigned to the 5000 m buffer zone. This approach assumes that the export coefficient values undergo a step-wise decay when originating from beyond the 50 m distance cutoff and that nutrient loading is somehow buffered beyond this distance.

The load was calculated by multiplying the land use area in each buffer zone by the modified export coefficient values. The phosphorus load from each buffer zone was added to obtain an overall loading from the landscape. Table 3-1 and 3-2 contain the modified phosphorus export

coefficients and the corresponding annual phosphorus loads for the various land uses in the watershed.

Table 3-1. Modified Total Phosphorus Export Coefficients for the Rio Hondo

LAND USE	50 m Buffer (kg/ha/yr)	500 m Buffer (kg/ha/yr)	5000 m Buffer (kg/ha/yr)
Urban	0.55[1]	0.28	0.14
Forest	0.07[2]	0.04	0.02
Shrubland	0.20[3]	0.10	0.05
Grasslands	0.10[4]	0.05	0.03

1. Source: Haith and Shoemaker 1987
2. Source: Rast and Lee 1983
3. Source: McFarland and Hauck 2001
4. Source: Johnes 1996

Table 3-2. Calculated Annual Total Phosphorus Loads to the Rio Hondo from Various Land Uses

LAND USE	AREA mi^2 (hectares)			DISTANCE –WEIGHTED TP Load lbs/day (kg/yr)		
	50 m Buffer	500 m Buffer	5 km Buffer	50 m Buffer	500 m Buffer	5 km Buffer
Urban	0.05 (14)	0.16 (40)	---	0.05 (7.5)	0.07 (11)	---
Forest	0.40 (96)	3.4 (875)	13 (3441)	0.04 (6.7)	0.19 (31)	0.36 (60)
Shrubland	0.02 (5.7)	0.28 (74)	1.3 (338)	0.01 (1.1)	0.04 (7.4)	0.10 (17)
Grasslands	0.01 (2.4)	0.13 (32)	2.4 (624)	0.001 (0.2)	0.01 (1.6)	0.09 (16)
TOTAL	**21.4[1] (5540)[1]**			**0.96[1] (159)[1]**		

1. Values rounded to three significant figures.

Natural Background Sources

Soil erosion and the decay of plant material and wild animal waste contribute background phosphorus loads from undeveloped land to the Rio Hondo. Available water quality concentrations from local streams similar to the Rio Hondo are used to determine background concentrations. Reference sites are relatively undisturbed by human influences. The definition of a reference condition ranges from a pristine, undisturbed state of a stream, to merely the "best available" or "best attainable" conditions. In the case of the Northern New Mexico streams used in this study, least and minimally impacted sites have been identified and used to determine background water quality. A value of one-half the detection limit was used when reference site TP concentrations were below the detection limit (Gilbert, 1987).

The background load to the Rio Hondo is calculated by multiplying the representative flow volume (in MGD) determined in Appendix C using USGS flow gage data and the background concentration (in mg P/L). A unit-less conversion factor of 8.34 is used to convert units to pounds per day (Appendix E). The total phosphorus background load for the assessment unit is summarized in Table 3-3.

Table 3-3. Calculated Total Phosphorus Background Load to the Rio Hondo

Time Interval	Representative 4Q3 Flow Volume (mgd)	Background Concentration (mg P/L)	Unit-less Conversion Factor	Estimated Annual TP Load (lbs/day)
Annual	3.73	0.017	8.34	**0.53**

3.1.2 Groundwater Loads

Septic tank disposal systems are not considered to be significant total phosphorus sources in ground water. Phosphates readily sorb to soil particles; consequently, phosphates do not travel far with ground water. Existing data for total phosphorus concentrations in soil below leach fields demonstrate this phenomenon. Phosphate concentrations 1 ft below a leach field were 10 mg P/L, while at 3 ft below the leach field they were 1 mg P/L (Oakley, 1999). Infiltration of phosphate from land applications is not considered significant for the same reason. Therefore, ground water loads of total phosphorus are not considered significant in the Rio Hondo.

3.1.3 Atmospheric Deposition

Atmospheric phosphorus can be found in both organic and inorganic dust particles. Particles of organic origin, such as pollen, will contain phosphorus, as do all living organisms. Mineral dust will contain varying levels of phosphorus depending on its source. Atmospheric deposition is only applied to stream surface areas; applying it to land areas would result in a double count of exported nutrient loads. The general atmospheric deposition rate for total phosphorus is 0.6 kg

P/ha/yr (USEPA, 1994a). With a creek surface area of 1.6 hectares (average of 8 feet wide and approximately 4 miles long), this source would contribute almost 1 kg/year, or roughly 0.006 lbs/day.

3.1.4 Summary of Current Annual Phosphorus Nonpoint Load by Source

The current annual load based on the calculations from the identified sources described in this section is 247 kg P/yr (1.49 lbs/day) and is summarized below in Table 3-4 and Figure 3-1.

Table 3-4. Summary of *Annual* Total Phosphorus Nonpoint Source Load

Source Type	Estimated Annual TP Load (lbs/day)
Land Uses (surface runoff)	0.96
Background (surface runoff)	0.53
Septic Tank Disposal Systems (ground water)	0
Air Deposition (surface water)	0.006
Total	**1.496**

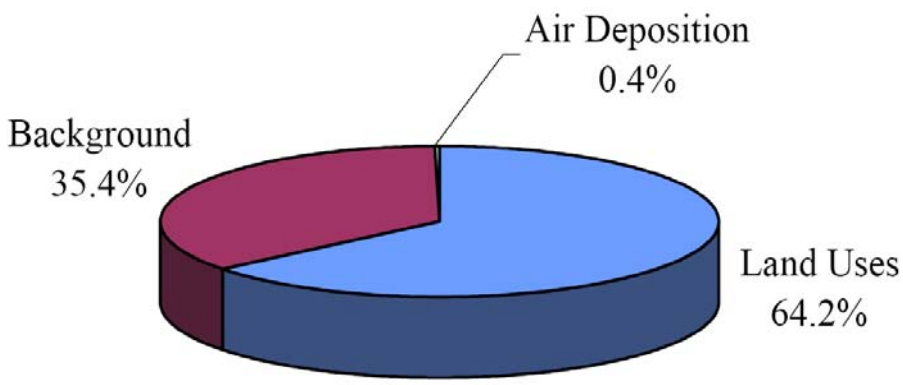

Figure 3-1. Annual Total Phosphorus Nonpoint Source Load by Source Type

3.2 Total Nitrogen

3.2.1 Surface Water Loads

Land use and natural sources were identified as potential sources of nitrogen to the Rio Hondo. This section provides discussion and estimates of the surface water loads from each of these sources.

Land Uses

It is assumed that the sources of total nitrogen in runoff from various land uses are the same as those identified for total phosphorus. To estimate total nitrogen loads from different land uses, nitrogen export coefficients can be used. Nitrogen generally reaches the Rio Hondo from land uses that are in close proximity to the stream because the hydrological pathways are shorter and have fewer obstacles than land uses located away from the riparian corridor. However, during spring snowmelt and in storm water runoff, those distant land uses can become hydrologically connected to the stream, transporting nutrients from the hillslopes to the stream during these time periods.

For this analysis, the Export Coefficient Model (Reckhow, et al., 1980) was modified to generate nitrogen loads from specific land uses by incorporating a distance-decay component in the export coefficient similar to the methods used by Johnes and Heathwaite (1997) and Endreny and Wood (2003). Nitrogen export weighting was based on distance from the stream with 50 m, 500 m, and 5000 m buffer zones. The largest unit-area load was assigned to the 50 m buffer zone and the smallest unit-area load was assigned to the 5000 m buffer zone. This approach assumes that the export coefficient values undergo a step-wise decay when originating from beyond the 50 m distance cutoff and that nutrient loading is somehow buffered beyond this distance.

The load was calculated by multiplying the land use area in each buffer zone by the modified export coefficient values. The nitrogen load from each buffer zone was added to obtain an overall loading from the landscape. Tables 3-5 and 3-6 contain modified nitrogen export coefficients and the corresponding annual nitrogen loads for the various land uses in the watershed.

Table 3-5. Modified Total Nitrogen Export Coefficients for the Rio Hondo

LAND USE	50 m Buffer (kg/ha/yr)	500 m Buffer (kg/ha/yr)	5000 m Buffer (kg/ha/yr)
Urban	2.5[1]	1.3	0.25
Forest	1.0[1]	0.50	0.10
Shrubland	0.60[2]	0.30	0.06
Grasslands	0.95[2]	0.48	0.10

1. Source: Rast and Lee 1983
2. Source: McFarland and Hauck 2001

Table 3-6. Calculated Annual Total Nitrogen Surface Water Loads to the Rio Hondo from Various Land Uses

LAND USE	AREA mi^2 (hectares)			DISTANCE –WEIGHTED TN Load lbs/day (kg/yr)		
	50 m Buffer	500 m Buffer	5 km Buffer	50 m Buffer	500 m Buffer	5 km Buffer
Urban	0.05 (14)	0.16 (40)	---	0.21 (34.0)	0.31 (50.1)	---
Forest	0.40 (96)	3.4 (875)	13 (3441)	0.58 (95.6)	2.64 (440)	2.08 (344)
Shrubland	0.02 (5.7)	0.28 (74)	1.3 (338)	0.02 (3.40)	0.13 (22.1)	0.12 (20.3)
Grasslands	0.01 (2.4)	0.13 (32)	2.4 (624)	0.01 (2.31)	0.09 (15.4)	0.36 (59.3)
TOTAL	**21.4[1] (5540)[1]**			**6.55[1] (1040)[1]**		

1. Values rounded to three significant figures.

Natural Background Sources

Soil erosion and the decay of plant material and wild animal waste contribute background nitrogen loads from undeveloped land to the Rio Hondo. Available water quality concentrations from local streams similar to the Rio Hondo are used to determine background concentrations. Reference sites are relatively undisturbed by human influences. The definition of a reference condition ranges from a pristine, undisturbed state of a stream, to merely the "best available" or "best attainable" conditions. In the case of the Northern New Mexico streams used in this study, least and minimally impacted sites have been identified and used to determine background water quality. A value of one-half the detection limit was used when reference site TN concentrations were below the detection limit (Gilbert, 1987).

As with phosphorus, the background load to the Rio Hondo is calculated by multiplying the representative flow volume (in MGD) determined in Appendix C using USGS flow gage data and the background concentration (in mg N/L). A unit-less conversion factor of 8.34 is used to convert units to pounds per day (Appendix E). The total nitrogen background load for the assessment unit is summarized in Table 3-7.

Table 3-7. Calculated Total Nitrogen Background Load to the Rio Hondo

Time Interval	Representative 4Q3 Flow Volume (mgd)	Background Concentration (mg N/L)	Unit-less Conversion Factor	Estimated Annual TN Load (lbs/day)
Annual	3.73	0.22	8.34	**6.84**

3.2.2 Ground Water Loads

Ground water that surfaces in the Rio Hondo also contributes to the nitrogen load. Septic tank disposal systems are considered to be a significant total nitrogen source in ground water. There are a total of 77 Liquid Waste Disposal Permits issued for on-site wastewater systems (i.e. septic tanks) in the Village of Taos Ski Valley (VTSV). Liquid Waste Disposal Permits are issued by NMED and are designed to accommodate septic systems that discharge less than 2,000 gallons of wastewater per day. An average yearly loading potential from septic tanks is 10.66 kg N per year (Marsh, 1998). The total annual nitrogen load to ground water from smaller on-site septic systems in the watershed therefore would be:

10.66 kg N/year * 77 units = 821 kg N/yr (4.96 lbs N/day).

There are also two NMED Ground Water Discharge Permits for on-site septic systems in the VTSV. One is issued to Austing Haus Bed and Breakfast and has a design capacity to discharge up to 4,000 gallons of wastewater per day. The other permit is issued to the Inn at TSV and has a design capacity to discharge up to 2,600 gallons of wastewater per day. The yearly loading potential from Marsh (1998) was weighted to accommodate the increase in wastewater using the following equations:

Austing Haus: 10.66 kg N/yr * (4,000 gal / 2,000 gal) = 21.3 kg N/yr (0.13 lbs N/day)
Inn at TSV: 10.66 kg N/yr * (2,600 gal / 2,000 gal) = 13.9 kg N/yr (0.08 lbs N/day)

Based on these calculations, the total annual nitrogen load to ground water from Austing Haus and the Inn at TSV is estimated to be 0.13 and 0.08 lbs N/day, respectively. The total annual nitrogen load to ground water from larger on-site septic systems in the watershed therefore would be 0.21 lbs N/day (35.2 kg N/year).

The total annual nitrogen load to ground water from on-site wastewater systems in the Village of TSV is the sum of the annual load from smaller septic systems and larger septic systems, or 5.17 lbs N/day (856 kg N/yr). Some of the nitrogen load will be removed through plant uptake, but site-specific uptake rates are not known and were not accounted for in the groundwater load estimate.

The current annual ground water load based on the calculations from the identified sources described in this section is summarized below in Table 3-8.

Table 3-8. Calculated Annual Total Nitrogen Load to the Rio Hondo from Ground Water Contributions

On-Site Septic Systems	Design Capacity (gal/day)	Nitrogen Export Coefficient (kg/system/yr)	Estimated Annual TN Load (kg N/yr)	Estimated Annual TN Load (lbs N/day)
L.W.D.P.[1]	<2000	11[3]	821	4.96
Austing Haus[2]	4000	21[4]	21.3	0.13
Inn @ TSV[2]	2600	14[4]	13.9	0.08
Total Nitrogen Load Attributable to Ground Water Sources				***5.17***

1. Liquid Waste Disposal Permits—a total of 77 are issued in the Village of TSV.
2. Groundwater Discharge Permits issued by NMED to Austing Haus and the Inn at TSV.
3. Source: Marsh 1998.
4. Source: Marsh 1998 (weighted for increased design capacities of 4000 and 2600 gallons/day).

3.2.3 Atmospheric Deposition

Atmospheric nitrogen can be found in both organic and inorganic dust particles. Particles of organic origin, such as pollen, will contain nitrogen, as do all living organisms. Mineral dust will contain varying levels of nitrogen depending on its source. Atmospheric deposition is only applied to stream surface areas; applying it to land areas would result in a double count of exported nutrient loads. The general atmospheric deposition rate for total nitrogen is 10 kg N per hectare per year (USEPA, 1994a). With a creek surface area of 1.6 hectares (average of 8 feet wide and approximately 4 miles long), this source would contribute almost 16 kg/year, or approximately 0.10 lbs/day.

3.2.4 Summary of Current Annual Nitrogen Nonpoint Source Load by Source

The current annual load based on the calculations from the identified sources described in this section is 3,046 kg N/yr (18.66 lbs/day) and is summarized below in Table 3-9 and Figure 3-2.

Table 3-9. Summary of *Annual* Total Nitrogen Nonpoint Source Load

Source Type	Estimated Annual TN Load (lbs/day)
Land Uses (surface runoff)	6.55
Background (surface runoff)	6.84
Septic Tank Disposal Systems (ground water)	5.17
Air Deposition (surface water)	0.097
Total	**18.66**

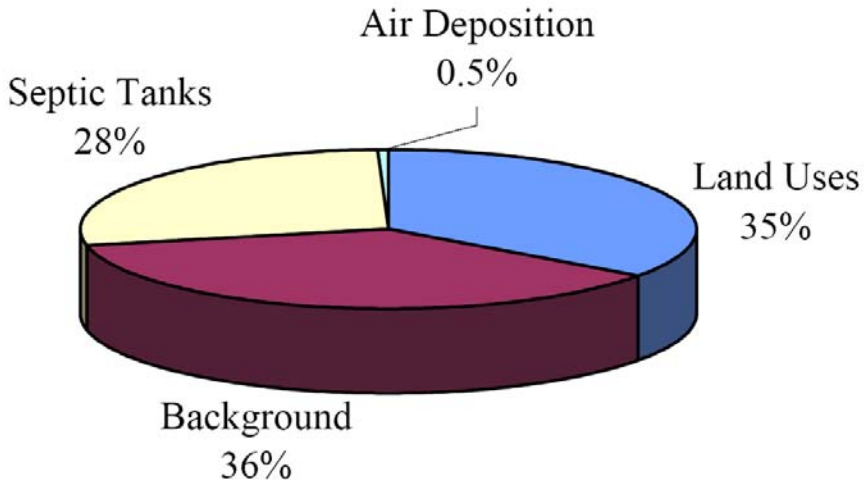

Figure 3-2. *Annual* Total Nitrogen Nonpoint Source Load by Source Type