3.3 WATER RESOURCES

Groundwater and surface water resources that could be potentially impacted by the proposed Project are described in this section. Potentially impacted water resources adjacent to the proposed pipeline route include major aquifers, wells, streams and rivers that would be crossed, and reservoirs and large lakes downstream of these crossings. In addition to their description, an evaluation of potential impacts to water resources from the construction and operation of the pipeline and measures to minimize impacts is provided.

3.3.1 Environmental Setting

3.3.1.1 Groundwater

Water Quality

Major aquifers and wells in the vicinity of the proposed Project route are described in the following sections by state. Available water quality information for the aquifers described in each state is presented in Table 3.3.1-1. Available studies and reports indicate that, in general, water within these aquifers exhibits high total dissolved solids (TDS) but in general is not contaminated with other toxic ions. Most often, high levels of TDS are caused by the presence of potassium, chlorides and sodium.

TABLE 3.3.1-1
Groundwater Quality of Select Subsurface Aquifers

Aquifer	State	County	Total Dissolved Solids (mg/liter)	Other Water Quality Information
Judith River Formation[a]	MT	Phillips, Valley	500-10,000	Sodium chloride rich in Valley County
Missouri River Alluvium[b]	MT	Valley	800-2,700	NA
Hells Creek/Fox Hills[c]	MT	McCone	500-1,800	Sodium bicarbonate rich
Fox Hills[c]	MT	Dawson, Prairie, Fallon	500-2,500	Sodium bicarbonate rich
Fort Union[c]	MT	McCone, Dawson, Prairie, Fallon	500-5,000	Sodium bicarbonate rich
Yellowstone R. Alluvium[d]	MT	Dawson, Prairie, Fallon	1,000-1,500	Calcium bicarbonate rich
Hells Creek/Fox Hills[e]	SD	Harding, Perkins, Meade	1,000-3,000	Sodium bicarbonate rich
Northern High Plains Aquifer (NHPAQ)/Ogallala Formation[f]	SD	Tripp	<500	Sodium bicarbonate rich
Pleistocene River Terrace[g]	SD	Tripp	30-4,000	NA
White River Alluvium[h]	SD	Tripp	287-688	Sodium bicarbonate rich
NHPAQ/Ogallala Formation[i]	NE	Keya Paha	100-250	NA
NHPAQ/Sand Hills Unit[j]	NE	Rock-Greeley	<500	NA
NHPAQ/Ogallala Formation[j]	NE	Greeley-Nance	<500	NA
NHPAQ/Platte River Unit[j]	NE	Merrick	<500	NA

TABLE 3.3.1-1 Groundwater Quality of Select Subsurface Aquifers				
Aquifer	**State**	**County**	**Total Dissolved Solids (mg/liter)**	**Other Water Quality Information**
NHPAQ/Eastern Nebraska Unit[j]	NE	Merrick-Jefferson	<500	NA
North Canadian River Alluvium and Terrace[k]	OK	Seminole	<500	Calcium bicarbonate rich
Red River Alluvium[k]	OK	Bryan	1,000-2,000	
Central Oklahoma[l]	OK	Lincoln	<500 (in upper 200 ft)	Calcium magnesium bicarbonate
Ada-Vamoosa[k]	OK	Osage-Pontotoc	<500	Sodium chloride; Sulfate
Arbuckle-Simpson[k]	OK	Coal-Pontotac	<500	Calcium bicarbonate rich
Trinity-Antlers[k]	OK/TX	Bryan, Atoka, Fannin	300-1,500	NA
Texas Coastal Uplands[m]	TX	Hopkins-Angelina	500-1,000	NA

Data obtained from the following sources: [a] Lobmeyer 1985, [b] Swenson and Drum 1955, [c] Smith et al. 2000, [d] La Rocque 1966, [e] Whitehead 1996, [f] Rich 2005, [g] Hammond 1994, [h] Cripe and Barari 1978, [i] Newport and Krieger 1959, [j] Stanton and Qi 2007, [k] Ryder 1996, [l] Carr and Marcher 1977, [m] Ryder and Ardis 2002.

NA = not applicable.

Aquifers and Depth to Groundwater

Initial information on depth to groundwater along the proposed Project corridor was provided by Keystone. Where readily accessible data on depth to groundwater was available (Montana, South Dakota, and Nebraska), water bearing zones less than 50 feet below ground surface (bgs) were identified by examining available well data. These data included static water level, screened interval, and driller well logs within 100 feet of the centerline. In Oklahoma, it was assumed that groundwater in alluvial floodplains was present at the surface. In Texas, it was assumed that groundwater across the alluvial floodplains was present throughout the floodplain at depths less than 50 feet bgs. Based on these data limitations, locations (by milepost) along the proposed Project corridor where estimated depth to groundwater is less than 50 feet are presented in Table 3.3.1-2.

TABLE 3.3.1-2 Water-Bearing Zones Less Than 50 Feet Below Ground Surface Beneath the Proposed ROW for the Project			
State/County	**Approximate Milepost or Range**	**Approximate Depth to Groundwater (feet bgs)[a]**	**Formation/Aquifer**
Steele City Segment			
Montana			
Phillips	2	8	Cretaceous Bearpaw Shale
Phillips	6	0	Cretaceous Bearpaw Shale
Phillips /Valley	25-26	<50	Frenchman Creek alluvium
Valley	27	0-45	Late-Cretaceous Judith River Formation
Valley	38-41	0-9	Rock Creek glacial/allluvial sediments
Valley	47	6	Late-Cretaceous Judith River Formation

TABLE 3.3.1-2 Water-Bearing Zones Less Than 50 Feet Below Ground Surface Beneath the Proposed ROW for the Project			
State/County	**Approximate Milepost or Range**	**Approximate Depth to Groundwater (feet bgs)[a]**	**Formation/Aquifer**
Valley	55-57	40-43	Late-Cretaceous Bearpaw Shale and Buggy Creek alluvium
Valley	66-72	7-63	Cherry Creek glacial/alluvial sediments
Valley	77-85	10-40	Porcupine Creek and Milk River alluvium
Valley	88	7-22	Milk River/Missouri River alluvial sediments
McCone	94	15	Late-Cretaceous Fox Hills Formation
McCone	99	26	Late-Cretaceous Hell Creek Formation
McCone	109	0	Late-Cretaceous Hell Creek Formation
McCone	119	20-30	Fort Union sands and Flying V Creek alluvium
McCone	122-123	<50	Figure Eight Creek alluvium
McCone	133-153	10-45	Fort Union sands; Redwater River alluvium; Buffalo Springs Creek alluvium; glacial drift
Dawson	159-160	10-50	Fort Union sands
Dawson	166-180	10-45	Clear Creek alluvium
Dawson	186-195	4-38	Clear Creek alluvium; Yellowstone River alluvium
Prairie	201-205	0-15	Cabin Creek alluvium
Prairie	209-214	18-40	Alluvium of merging creeks
Fallon	227	<50	Dry Fork Creek alluvium
Fallon	231-234	0	Glacial drift/alluvium
Fallon	235-238	18-45	River alluvium of Dry Creek and its tributaries
Fallon	242-250	5-26	Sandstone Creek and Butte Creek alluvium
Fallon	257-262	0-37	Hidden Water Creek; Little Beaver Creek alluvium
Fallon	264-272	0	Mud Creek and Soda Creek alluvium
Fallon	275-279	0	North and South Coal Bank Creek alluvium
Fallon	281-282	<50	Box Elder Creek alluvium
South Dakota			
Harding	289-290	<50	Shaw Creek alluvium
Harding	291-292	<50	Little Missouri River alluvium
Harding	298-301	<50	Various creeks -alluvium
Harding	304-306	<50	Jones Creek alluvium
Harding	317-319	15-40	South Fork Grand River alluvium
Harding	322-324	<50	Buffalo Creek/Clarks Fork Creek alluvium
Harding	329	<50	West Squaw Creek alluvium
Harding	339	20	Red Butte Creek alluvium
Harding/Butte	351-355	<50	North Fork Moreau River alluvium
Meade	380-387	15-45	Tertiary or alluvial

TABLE 3.3.1-2
Water-Bearing Zones Less Than 50 Feet Below Ground Surface Beneath the Proposed ROW for the Project

State/County	Approximate Milepost or Range	Approximate Depth to Groundwater (feet bgs)[a]	Formation/Aquifer
Meade	390-394	25	Tertiary or alluvial
Meade	399	18	Sulphur Creek alluvium
Meade	403-404	14-44	Spring Creek alluvium
Meade	407-408	14	Red Owl Creek alluvium
Meade	411	3	Narcelle Creek alluvium
Meade	425	5	Cheyenne River alluvium
Pennington/Haakon	432-437	<50	Alluvial
Haakon	442	12	Alluvial
Haakon	475	37	Alluvial
Haakon	478-481	14-25	Bad River alluvium
Jones	518-519	6	Alluvial
Lyman	535-536	6	White River alluvium
Tripp	539	23	NHPAQ/ Ogallala Formation
Tripp	561-564	3-9	NHPAQ/ Ogallala Formation
Tripp	570 -595	6-25	NHPAQ/ Ogallala Formation
Nebraska			
Keya Paha	597-600	<50	Keya Paha River alluvium
Keya Paha/Rock	603-616	<50	NHPAQ/ Ogallala Formation and Sandhills Unit.
Keya Paha	613-614	<50	Niobrara River alluvium
Rock /Holt/Garfield	624-675	<50	NHPAQ/ Ogallala Formation and Sandhills Unit. with flowing wells, groundwater seeps, and shallow lakes
Wheeler	692-697	<50	Cedar River alluvium
Nance	726-729	<50	South Branch Timber Creek alluvium
Nance/Merrick	737-757	<10[b]-55	Platte River floodplain alluvium
York	778-779	<50	Beaver Creek alluvium
York	788-789	<10[b]-90	West Fork Big Blue River alluvium
Fillmore/Saline	807-822	<50	South Fork Turkey Creek alluvium
Jefferson	834-836	<10[b]-50	South Fork Swan Creek alluvium
Jefferson	847	<50	Tributary to Big Indian Creek alluvium
Gulf Coast Segment			
Oklahoma			
Lincoln	1-4	0	Wildhorse Creek alluvium
Lincoln/Creek	19-20	0	Euchee Creek alluvium
Creek/Okfuskee	22-25	0	Deep Fork River alluvium
Okfuskee	28-29	0	Little Hilliby Creek alluvium

TABLE 3.3.1-2 Water-Bearing Zones Less Than 50 Feet Below Ground Surface Beneath the Proposed ROW for the Project			
State/County	**Approximate Milepost or Range**	**Approximate Depth to Groundwater (feet bgs)[a]**	**Formation/Aquifer**
Okfuskee	30-31	0	Hilliby Creek alluvium
Okfuskee	33	40	Very High Groundwater sensitivity area
Okfuskee/Seminole	38-39	47	North Canadian River - Very High Groundwater Sensitivity Area
Seminole	43-45	0	Sand Creek alluvium
Seminole	47-48	0	Little Wewoka Creek alluvium
Seminole	50-51	0	Wewoka Creek alluvium
Seminole/Hughes	58-61	0	Wewoka Creek alluvium
Hughes	66-68	0	Bird Creek -Very High Groundwater sensitivity area
Hughes	70-71	0	Little River alluvium
Hughes	74-76	0	Canadian River alluvium
Coal	87-88	0	Muddy Boggy Creek alluvium
Atoka	127-130	0	Clear Boggy Creek alluvium
Bryan	133-134	0	Long Branch alluvium
Bryan	145	0	Whitegrass Creek alluvium
Bryan	155-156	0	Red River alluvium
Texas			
Fannin	156-161	<50	Red River alluvium
Lamar	170	<50	Sanders Creek alluvium
Lamar	172	<50	Cottonwood Creek alluvium
Lamar/-Delta	187-191	<50	North Sulfur River alluvium
Delta/Hopkins	201-202	<50	South Sulfur River alluvium
Hopkins	212-213	<50	White Oak Creek alluvium
Hopkins	216-217	<50	Stouts Creek alluvium
Franklin	227-228	<50	Big Cypress Creek alluvium
Wood/Upshur	256-257	<50	Big Sandy Creek alluvium
Upshur	260-263	<50	Sabine River alluvium
Cherokee	297-301	<50	Striker Creek alluvium
Rusk	308-313	<50	East Fork Angelina River alluvium
Nacogdoches/ Cherokee	330-336	<50	Angelina River floodplain alluvium
Angelina	345-346	<50	Neches River alluvium
Angelina	350-353	<50	Neches River alluvium
Angelina/Polk	360-369	<50	Neches River alluvium
Polk	374-375	<50	Bear Creek alluvium
Polk	380	<50	Jones Creek alluvium

TABLE 3.3.1-2 Water-Bearing Zones Less Than 50 Feet Below Ground Surface Beneath the Proposed ROW for the Project			
State/County	**Approximate Milepost or Range**	**Approximate Depth to Groundwater (feet bgs)[a]**	**Formation/Aquifer**
Polk	400-406	<50	Menard Creek alluvium
Polk/Liberty	412-431	<50	Middle Pleistocene sand/silt along Trinity River
Liberty	432-446	<50	Willow Creek/Pine Island Bayou floodplain alluvium
Jefferson	448-480	<50	Late Pleistocene mud/silt in floodplains of various rivers that coalesce.

[a] bgs = below ground surface; based on available well data from Keystone 2009, except where noted for footnote b.

[b] Data from NEDNR 2010.

Note: Mileposting for each segment of the Project starts at 0.0 at the northernmost point of each segment, and increases in the direction of oil flow.

Supplemental information on groundwater occurrence and depth to groundwater by state has been evaluated (see Figures 3.3.1-1 through 3.3.1-5) to address concerns expressed in comments on the draft EIS relative to the Northern High Plains Aquifer (NHPAQ) system (including the Ogallala aquifer) and concerns relative to other aquifers along the proposed Project corridor. The supplemental analysis provides more information on the likely occurrence of potable groundwater in water wells within 1 mile of the proposed pipeline centerline using publicly available and searchable databases maintained by water resource agencies within each state that would be crossed by the proposed Project. The databases were searched for domestic, irrigation, and public water supply well data. The analysis of impacts on water supplies for human consumption also applies to water intakes for industrial and municipal use. Data accessed included well locations, well total depth, and depth to first water (if available) or static water level (see Appendix E of this SDEIS). The screened intervals for individual water wells were not readily available in these databases. Since the screened intervals are not available, it is not possible in all cases to correlate static water level to likely depth to first water. Given limitations and variations in data quality from state to state, five general categories that relate well depth and reported water levels (first water or static water level) to likely water depth were created. These categories are:

- Category A: very shallow water depth likely with reported water level less than or equal to 10 feet bgs and total well depth less than or equal to 50 feet bgs;
- Category B: shallow water depth likely with reported water level between 10 and 50 feet bgs and total well depth less than or equal to 50 feet bgs;
- Category C: water depth unclear but potentially very shallow since reported water level is less than or equal to 10 feet bgs and total well depth is greater than 50 feet bgs (reported water level could indicate very shallow water depth if well screened in upper 50 feet or deep water depth if well screened at deeper interval under artesian conditions);
- Category D: water depth unclear but potentially shallow since reported water level is between 10 and 50 feet bgs and total well depth is greater than 50 feet bgs (reported water level could indicate shallow water depth if well screened in upper 50 feet or deep water depth if well screened at deeper interval under artesian conditions); and
- Category E: deep water depth likely with reported water level greater than 50 feet bgs and total well depth greater than 50 feet bgs.

Information on key aquifers that would be crossed by the proposed Project and additional information on likely depth to groundwater based on the above categories is presented by state in the following subsections.

Montana

Key Aquifers

The proposed pipeline route is present in the Great Plains physiographic province in Montana (Thornbury 1965). Regionally, aquifers beneath the proposed route are part of the Northern Great Plains aquifer system (Whitehead 1996). In Montana, aquifers consist of unconsolidated alluvial and/or glacial aquifers, lower Tertiary-aged aquifers, and upper Cretaceous-aged aquifers (see Figure 3.3.1-1). Groundwater resources along alternate pipeline routes considered in Montana are described in Appendix I.

In northern Montana, in Phillips and Valley counties, glacial till is present up to 100 feet thick. The till is relatively impermeable and acts as a confining layer above the Cretaceous-aged Judith River Formation and Clagett Formation (Whitehead 1996). The Judith River Formation water table is present at approximately 150 to 500 feet bgs. Wells typically yield 5 to 20 gallons per minute (gpm). Additionally, the glacial till contains local permeable zones of coarse glacial outwash less than 50 feet bgs that provide irrigation water. Most groundwater use in Valley County comes from shallow alluvial aquifers along major river drainages such as the Milk River and Missouri River (Whitehead 1996).

In McCone County, the proposed route crosses the upper-Cretaceous Hells Creek/Fox Hills aquifer and the lower Tertiary Fort Union aquifer. Permeable sandstones of the Hells Creek/Fox Hills aquifer yield 5 to 20 gpm; most wells are drilled to depths of 150 to 500 feet bgs (Whitehead 1996). The lower Tertiary Fort Union aquifer consists of interbedded sandstones, mudstones, shale, and coal seams. Water-bearing zones are found in the sandstone layers. The aquifer is confined in most areas. Well yields are typically 15 to 25 gpm; most wells are drilled to depths of 50 to 300 feet bgs (Lobmeyer 1985); water depths typically range from 100 to 150 feet bgs (Swenson and Drum 1955).

Beneath the proposed route in Dawson, Prairie, and Fallon counties lies the Lower Yellowstone aquifer system which contains groundwater in the lower Tertiary Fort Union Formation. In this area, the Fort Union Formation is a shallow bedrock aquifer that is used as a groundwater resource in these three counties. The Yellowstone River contains abundant alluvial material along its banks which contain shallow aquifers that are often used for water supply. Well yields in the shallow aquifers along the Yellowstone River range from 50 to 500 gpm (LaRocque 1966). Additionally, shallow alluvial aquifers are also present at stream crossings including Clear Creek, Cracker Box/Timber Creek, Cabin Creek, Sandstone Creek, and Butte Creek.

The proposed Project pipeline route does not cross any sole-source aquifers in Montana, as designated by EPA Region 8 (EPA 2009).

Nearby Public Water Supply Wells and Private Water Wells

No public water supply (PWS) wells or source water protection areas (SWPA) are located within 1 mile of the centerline of the pipeline in Montana. A total of eight private water wells are located within approximately 100 feet of the proposed pipeline route within McCone, Dawson, Prairie, and Fallon counties.

Likely Depth to Groundwater

Estimates of the likely depth to groundwater at existing well locations within 1 mile of the proposed pipeline in Montana are provided in Figure 3.3.1-1. As depicted in Figure 3.3.1-1, the numbers of wells within 1 mile of the proposed pipeline that fall within each groundwater depth category are as follows:

- Category A (very shallow): 51
- Category B (shallow): 22
- Category C (unclear but potentially very shallow): 46
- Category D (unclear but potentially shallow): 38
- Category E (deep): 59

South Dakota

Key Aquifers

In South Dakota the proposed pipeline route is present in the Great Plains physiographic province (Thornbury 1965). In northern and north-central South Dakota, aquifers beneath the proposed route are part of the Northern Great Plains Aquifer system (Whitehead 1996). Key aquifers in South Dakota are depicted in Figure 3.3.1-2. These aquifers include the upper-Cretaceous Fox Hills and Hells Creek aquifers in Harding, Perkins, and Meade counties. The town of Bison uses groundwater from the Fox Hills aquifer for its water supply. These municipal wells are 565 to 867 feet deep and yield up to 50 gpm (Steece 1981). Shallow alluvial aquifers are also present at stream crossings including Little Missouri River, South Fork Grand River, Clarks Fork Creek, Moreau River, Sulphur Creek, Red Owl Creek, and Cheyenne River.

In Haakon, Jones, and Lyman counties major water-producing aquifers are not present. The proposed route is underlain by the upper-Cretaceous Pierre Shale which is not an aquifer. The floodplains of the Bad River and the White River contain shallow alluvial aquifers that are used for water supply.

In southern South Dakota, the proposed route is underlain by the northern portion of the NHPAQ system and contains Tertiary-aged aquifers and Pleistocene-aged river terrace aquifers (Whitehead 1996). This aquifer system is located primarily in Nebraska, but underlies portions of five states, including South Dakota. Tertiary-aged aquifers include the Ogallala Formation and the Brule and Arikaree Formation. Depth to groundwater of the Ogallala Formation is typically 10 to 70 feet bgs (Hammond 1994) with wells yielding 250 to 750 gpm.

The proposed pipeline route does not cross any sole-source aquifers in South Dakota, as designated by EPA Region 8 (EPA 2009).

Nearby Public Water Supply Wells and Private Water Wells

One PWS well (associated with the Colome SWPA) is identified within 1 mile of the centerline of the pipeline in Tripp County. This PWS wells is screened at relatively shallow depth (reportedly less than 54 feet bgs) within the Tertiary Ogallala aquifer. The proposed Project would pass through the Colome SWPA in Tripp County. No private water wells are located within approximately 100 feet of the proposed pipeline route in South Dakota.

Likely Depth to Groundwater

Estimates of the likely depth to groundwater at existing well locations within 1 mile of the proposed pipeline in South Dakota are provided in Figure 3.3.1-2. As depicted in Figure 3.3.1-2, the numbers of wells within 1 mile of the proposed pipeline that fall within each groundwater depth category are as follows:

- Category A (very shallow): 11
- Category B (shallow): 13
- Category C (unclear but potentially very shallow): 5
- Category D (unclear but potentially shallow): 40
- Category E (deep): 58

Nebraska

Key Aquifers

The proposed route in Nebraska also overlies the NHPAQ system. The NHPAQ system supplies 78 percent of the public water supply and 83 percent of irrigation water in Nebraska (Emmons and Bowman 1999). Many commenters on the draft EIS requested additional information on portions of the NHPAQ system that could be impacted by the proposed Project.

In Nebraska, the NHPAQ system includes five main hydrogeologic units, including the Brule and Arikaree Formation, the Eastern Nebraska Unit, the Ogallala Formation, the Platte River Valley Unit, and the Sand Hills Unit (see Figure 3.3.1-6). These units occur over approximately 64,400 square miles in Nebraska. The proposed Project ROW would extend 247 linear miles through areas underlain by the NHPAQ system. The pipeline would immediately overlie 81 miles of the Eastern Nebraska Unit, 62 miles of the Ogallala Formation, 12 miles of the Platte River Valley Unit, and 92 miles of the Sand Hills Unit.

The type of soil that overlies the NHPAQ system generally consists of silt loam and sand, although clay loam, loam, and sandy loam are also present (Stanton and Qi 2007). In the High Plains Aquifer, which includes the NHPAQ system, hydraulic conductivity (a measurement of the rate of movement of water through a porous medium such as an aquifer or a soil) ranges from 25 to 100 feet per day (ft/d) in 68 percent of the aquifer and averages 60 ft/d (Weeks et al. 1988). In general, ground water velocity (which also takes into account the porosity and the hydraulic gradient [slope of the water table]) in the High Plains Aquifer is 1 ft/d and flows from west to east (Luckey et al. 1986).

The soils of the Sand Hills Unit of the NHPAQ system are derived primarily from aeolian dune sands and are characterized by very low organic and clay/silt fractions. According to the USGS, the hydraulic conductivity of the Northern High Plains aquifer is relatively small, particularly in the Sand Hills north of the Platte River (Gutentag et al. 1984; Luckey et al. 1986). The aquifer material in this region is composed mainly of fine sands and silts with little hydraulic conductivity (Luckey et al. 1986). Estimates of the hydraulic conductivity of the Sand Hills Unit of the NHPAQ system are variable, with a high end estimate of 50 ft/d (Gutentag et al. 1984) and a lower range estimate of 40 ft/d to 13 ft/d (Lappala 1978). Hydraulic conductivity values for the dune sands at the surface in the Sand Hills Unit range from 16.4 ft/d to 23.0 ft/d near the ground surface (8 inches in depth) (Wang, et al, 2006). At intermediate depths within the root zone, hydraulic conductivity values range from 26.3 ft/d to 32.8 ft/d in lowland areas and 32.8 ft/d to 49.2 ft/d in higher areas. In the lower boundary of the root zone, at approximately 6.5 ft bgs, hydraulic conductivities ranged from 42.7 ft/d to 49.2 ft/d (Wang et al. 2006). These values were based on direct in-situ measurements by constant head permeameter.

In the eastern portion of the Sand Hills Unit, non dune derived soils originate from glacial loess and drift deposits (Sullivan, 1994). These fine-grained loess deposits further to the east can be as thick as 200 feet and can locally restrict water flow where fractures are absent (USGS SIR 2006-5138, Johnson 1960).

Certain areas within the Ogallala Formation of the NHPAQ system contain soils or lithologic zones that inhibit downward contaminant migration (Gurdak et al. 2009). In these areas transport of dissolved chemicals from the land surface to the water table is slower, taking decades to centuries (Gurdak et al. 2009). However even in these areas, localized preferential flow paths do exist that could enable dissolved chemicals to move at an increased rate through the unsaturated zone to the water table. These preferential flow paths are more likely to be present beneath topographic depressions, where precipitation or surface water collects. Preferential pathways with lower infiltration rates are more likely to be present in areas of fine-grained sediments or beneath flat terrain where free-standing water does not pool or collect (Gurdak et al. 2009). These areas within the Ogallala Formation of the NHPAQ system consist of geologic units that comprise unconsolidated sand, gravel, clay, and silt along with layers of calcium carbonate and siliceous cementation (Stanton and Qi 2007). According to the USGS water quality report, a zone of post-deposition cementation is present in many of these areas near the top of the Ogallala Formation, creating an erosion resistant ledge. The Ogallala Formation also contains localized ash beds. These cementation zones and ash layers would serve as localized aquitards within the Ogallala Formation and would tend to inhibit vertical migration of dissolved contaminants.

In Keya Paha County (northern Nebraska), wells yield 100 to 250 gpm (Newport and Krieger 1959). Alluvial aquifers are also present at the Keya Paha River and the Niobrara River. The Niobrara River is used as a source of irrigation and municipal water supply.

From Rock through Greeley counties, the project route is underlain by the NHPAQ system (Sand Hills Unit and Ogallala Formation). The Sand Hills Unit typically has a shallow water table less than 30 feet bgs and is therefore a potential concern (Stanton and Qi 2006). Alluvial aquifers are also present along the Elkhorn River and its tributaries and the Cedar River.

Beneath Nance, Merrick, and Hamilton counties, the project route is again underlain by the Ogallala Formation of the NHPAQ system to the Loup River. From the Loup River to the Platte River, the project route is underlain by the Platte River Valley Unit of the NHPAQ system. Additional shallow aquifers crossed by the proposed Project include the alluvial aquifer of the South Branch Timber Creek and the alluvial aquifer of the Loup River (used for irrigation and domestic water supply).

South of the Platte River, the proposed route crosses the Eastern Nebraska Unit of the NHPAQ system, used for irrigation, domestic, and municipal water supply. Hordville’s public water supply comes from wells screened within this aquifer from 160 to 262 feet bgs (Keech 1962).

From York to Jefferson counties, the depth to groundwater is on average 80 feet bgs within the Eastern Nebraska Unit of the NHPAQ system (Stanton and Qi 2006). Additionally, the project route crosses alluvial aquifers along Beaver Creek, the West Fork of the Big Blue River, and the alluvial floodplain of the South Fork Turkey Creek.

While the water quality in the NHPAQ system is suitable for drinking and as irrigation water, impacts from farming operations are present in areas of shallow groundwater. In areas where crop irrigation occurs and shallow groundwater is present, elevated levels of fertilizers, pesticides, and herbicides occur, including nitrate and atrazine, indicative of impact caused by farming operations. Concentrations of these constituents are generally higher in the near-surface groundwater (Stanton and Qi 2007).

The proposed pipeline route does not cross any EPA designated sole-source aquifers in Nebraska (EPA 2009).

Nearby Public Water Supply Wells and Private Water Wells

Eight PWS wells are present within 1 mile of the centerline of the proposed route in Hamilton, York, Fillmore, Saline, and Jefferson counties. The proposed route would not however pass through any identified PWS wellhead protection areas. SWPAs within 1 mile of the proposed Project include those for the towns of Ericson, Hordville, McCool Junction, Exeter, Steele City and the Rock Creek State Park. Additional SWPAs within 1 mile of the proposed Project include those mapped in Hamilton County near Milepost (MP) 772 and York County near MP 781 and 783. A total of 29 private water wells are located within approximately 100 feet of the proposed pipeline route within Greeley, Merrick, Hamilton, York, Fillmore, and Jefferson counties.

Likely Depth to Groundwater

Estimates of the likely depth to groundwater at existing well locations within 1 mile of the proposed pipeline in Nebraska are provided in Figure 3.3.1-3. As depicted in Figure 3.3.1-3, the numbers of wells within 1 mile of the proposed pipeline that fall within each groundwater depth category are as follows:

- Category A (very shallow): 183
- Category B (shallow): 62
- Category C (unclear but potentially very shallow): 115
- Category D (unclear but potentially shallow): 205
- Category E (deep): 629

Additionally, a USGS analysis suggests that depth to groundwater in the NHPAQ system is variable and ranges from 0 to 272 feet bgs (Stanton and Qi 2007). The median depths to groundwater in the NHPAQ units that would be crossed by the proposed Project in Nebraska are:

- Ogallala Formation: 110 feet bgs
- Eastern Nebraska Unit: 79 feet bgs
- Sand Hills Unit: 20 feet bgs
- Platte River Valley Unit: 5 feet bgs

The well locations where estimated groundwater depth falls within Categories A and C can be used to estimate the distance along the proposed pipeline corridor in Nebraska where water depths less than or equal to 10 feet bgs could be encountered. These data suggest that approximately 65 miles of the proposed pipeline corridor in Nebraska could encounter groundwater at a depth below ground surface less than or equal to 10 feet (see Figure 3.3.1-3). The majority of these areas are present in the Sand Hills Unit and the Platte River Valley Unit and overlie the deeper Ogallala Formation.

Kansas

Construction planned in Kansas as part of the proposed Project comprises two new pump stations located in Clay and Butler counties along the existing Cushing Extension of the Keystone pipeline. These counties are underlain by the near surface Permian-aged Flint Hills aquifer. The Flint Hills aquifer, a source for numerous small springs, exhibits yields up to 1,000 gallons per minute and is a source for potable water supplies.

Oklahoma

Key Aquifers

The majority of water supply in eastern Oklahoma comes from shallow alluvial and terrace aquifers (Ryder 1996). Key aquifers in Oklahoma are depicted in Figure 3.3.1-4. Alluvial aquifers are located within the floodplains of major rivers and terrace aquifers are present in historical floodplain terraces. Alluvial aquifers contain a shallow unconfined water table while terrace aquifers typically contain a water table depth of 30 to 50 bgs (Ryder 1996). Major rivers and floodplains that contain these aquifers include the North Canadian River, the Canadian River, and the Red River at the state's southern border. Well yields for these aquifers are up to 1,000 gpm for the North Canadian River aquifer, up to 500 gpm for the Canadian River aquifer, and 200 to 500 gpm for the Red River aquifer (Ryder 1996). Alluvial and terrace aquifers consist of Quaternary and late tertiary deposits of sand and gravel interbedded with clay and silt. These aquifers are used for water supply in eastern Oklahoma (Ryder 1996).

Deeper bedrock aquifers include the Garber-Wellington aquifer, the Vamoosa-Ada aquifer, and the Antlers aquifer. The Garber-Wellington aquifer consists of confined and unconfined formations. Well yields range from 70 to 475 gpm (Carr and Marchur 1977) and well depths can be as shallow as 20 feet bgs but are also screened at depths up to 1,000 feet bgs. This aquifer lies adjacent to the west of the proposed route in central Oklahoma. The Vamoosa-Ada aquifer is present beneath the proposed route from Osage to Pontotoc counties and is composed of sandstone and interbedded shale. Wells typically yield 25 to 150 gpm and are used for domestic supply (Ryder 1996). The Antlers aquifer is located beneath the Red River at the state line between Oklahoma and Texas. In Atoka County, the aquifer is present in Cretaceous-aged sandstone and is unconfined; the aquifer is confined beneath Bryan County to the state border. Water is used for domestic, irrigation, commercial and public water supply (Ryder 1996).

Although the proposed pipeline route does not cross any sole-source aquifers in Oklahoma, the route would pass to the east of the Arbuckle-Simpson aquifer, a designated sole-source aquifer by EPA Region 6 (EPA 2009). From the center line of the pipeline, the eastern extent of the Arbuckle-Simpson aquifer is approximately 12 miles to the west. The Arbuckle-Simpson aquifer underlies the Arbuckle Mountains and Arbuckle Plains in south central Oklahoma and is composed of sandstone and interbedded shale (Ryder 1996). Water is present to depths up to 3,000 feet bgs and wells typically yield 100 to 500 gpm.

Nearby Public Water Supply Wells and Private Water Wells

Within 1 mile of the proposed pipeline route in Hughes, Coal, and Bryan counties, 28 PWS wells are present. The number of private water wells located within 100 feet of the proposed pipeline route in Oklahoma is unknown.

Likely Depth to Groundwater

Estimates of the likely depth to groundwater at existing well locations within 1 mile of the proposed pipeline in Oklahoma are provided in Figure 3.3.1-4. As depicted in Figure 3.3.1-4, the numbers of wells within 1 mile of the proposed pipeline that fall within each groundwater depth category are as follows:

- Category A (very shallow): 1
- Category B (shallow): 2

- Category C (unclear but potentially very shallow): 41
- Category D (unclear but potentially shallow): 60
- Category E (deep): 64

Texas

Key Aquifers

Three principal aquifers are present beneath the proposed Project route, including the Trinity aquifer located south of the Red River at the state line, the Texas Coastal Uplands aquifer system from Hopkins County to the Neches River in Angelina County, and the Texas Coastal Lowlands aquifer system from Polk to Jefferson counties (Ryder 1996). Key aquifers in Texas are depicted in Figure 3.3.1-5. These aquifer systems are composed of multiple aquifers that are described below.

The Trinity aquifer consists of Cretaceous-aged sandstone, siltsone, clay, conglomerate, shale, and limestone. Wells yield 50 to 500 gpm and wells are typically 50 to 800 feet deep (Ryder 1996). Water is used for domestic and agricultural use.

The Texas Coastal Uplands aquifer system consists of two main aquifers: the Paleocene/Eocene Carrizo-Wilcox aquifer and the Eocene Claiborne aquifer, which is situated above the Carrizo-Wilcox aquifer. Both aquifers consist of sand, silt, gravel, and clay and are used extensively for agricultural irrigation, domestic, municipal, and industrial water supply. Groundwater in the Carrizo-Wilcox aquifer is present under unconfined and artesian conditions. Water-table conditions usually occur in areas where the aquifer outcrops, and artesian conditions occur where the aquifer is overlain by confining beds. Well yields are usually 500 gal/min (Thorkildsen and Price 1991).

From Polk County to the southern extent of the proposed route, the ROW is present above the Texas Coastal Lowlands aquifer system. The three main aquifers in this system are the Miocene Jasper aquifer, overlain by the late Tertiary Evangeline, which is overlain by the Quaternary Chicot aquifer (Ryder 1996). These three aquifers are composed of sand with interbedded silt and clay. The Evangeline and Chicot aquifers are used extensively for water supply in this area; water levels range from 100 to 300 feet bgs.

The proposed pipeline route does not cross any sole-source aquifers in Texas, as designated by EPA Region 6 (EPA 2009).

Nearby Public Water Supply Wells and Private Water Wells

Within 1 mile of the proposed Gulf Coast Segment pipeline route in Lamar, Wood, Smith, Rusk, Nacogdoches, Angelina, Polk, and Liberty counties, 53 PWS wells are present. Within 1 mile of the proposed Houston Lateral pipeline route, 145 PWS wells are present in Liberty and Harris counties. The proposed Project would pass within 1 mile of 36 SWPAs in Texas. A total of three private water wells are located within approximately 100 feet of the proposed pipeline route within Smith and Chambers counties.

Likely Depth to Groundwater

Estimates of the likely depth to groundwater at existing well locations within 1 mile of the proposed pipeline in Texas are provided in Figure 3.3.1-5. As depicted in Figure 3.3.1-5, the numbers of wells within 1 mile of the proposed pipeline that fall within each groundwater depth category are as follows:

- Category A (very shallow): 11
- Category B (shallow): 11
- Category C (unclear but potentially very shallow): 52
- Category D (unclear but potentially shallow): 25
- Category E (deep): 55

3.3.1.2 Surface Water

Surface water resources that would be crossed by the proposed Project are located within three water resource regions (Seaber et al. 1994):

- Missouri River Region (Montana, South Dakota, Nebraska, and northern Kansas);
- Arkansas-White-Red Rivers Region (southern Kansas, Oklahoma, and northern Texas); and
- Texas-Gulf Rivers Region (Texas).

Stream and river crossings are described below by state. Additionally, reservoirs and larger lakes that are present within 10 miles downstream of these crossings are listed in Appendix E. Levees, water control structures, and flood protection structures along the proposed route are also presented in Appendix E.

Montana

Waterbodies Crossed

As presented in Appendix E, 350 waterbody crossings would occur in Montana along the proposed Project route. Of the 350 crossings 19 are perennial streams, 114 are intermittent streams, 201 are ephemeral streams, 15 are canals, and 1 is a man-made pond. Based on stream width, adjacent topography, adjacent infrastructure, and sensitive environmental areas, three rivers in Montana would be crossed using the horizontal directional drill (HDD) method. These rivers include:

- Milk River in Valley County (approximately 100 feet wide, MP 83);
- Missouri River in Valley and McCone counties (approximately 1,000 feet wide, MP 89); and
- Yellowstone River in Dawson County (approximately 780 feet wide, MP 196).

The remaining 347 waterbodies would be crossed using one of several non-HDD methods described in the CMR Plan (Appendix B). The crossing method for each waterbody would be depicted on construction drawings but would ultimately be determined based on site-specific conditions at the time of crossing. Surface water resources along alternate pipeline routes considered in Montana are described in Appendix I. Several route variations have been suggested to either reduce impacts at a crossing or to address landowner concerns. These are also summarized in Appendix I. Bureau of Reclamation (Reclamation) canal crossings would include one in Valley County near MP 85 and three in Dawson County from MP 194 to MP 196 (see Figure 2.1-1). For these crossings, Keystone would apply general design requirements consistent with Reclamation facility crossing criteria (see Appendix E).

Sensitive or Protected Waterbodies

The following streams and rivers that would be crossed by the proposed Project route in Montana contain state water quality designations or use designations (Appendix E). These waterbodies include:

- Dunham Coulee and Corral Coulee, in Phillips County
- Missouri River, Frenchman Creek, East Fork Cache Creek, Hay Coulee, Rock Creek, Willow Creek, Lime Creek, Brush Fork, Bear Creek, Unger Coulee, Buggy Creek, Alkali Coulee, Wire Grass Coulee, Spring Creek, Mooney Coulee, Cherry Creek, Spring Coulee, East Fork Cherry Creek, Lindeke Coulee, Espeil Coulee, and Milk River in Valley County
- West Fork Lost Creek, Lost Creek, Shade Creek, Jorgensen Coulee, Cheer Creek, Bear Creek, South Fork Shade Creek, Flying V Creek, Figure Eight Creek, Middle Fork Prairie Elk Creek, East Fork Prairie Elk Creek, Lone Tree Creek, Tributary to West Fork Lost Creek, Redwater Creek, and Buffalo Springs Creek in McCone County
- Cottonwood Creek, Berry Creek, Hay Creek, Upper Seven Mile Creek, Clear Creek, Cracker Box Creek, Side Channel Yellowstone River, and Yellowstone River in Dawson County
- Cabin Creek, West Fork Hay Creek, and Hay Creek in Prairie County
- Dry Fork Creek, Pennel Creek, Sandstone Creek, Red Butte Creek, Hidden Water Creek, Little Beaver Creek, Soda Creek, North Fork Coal Bank Creek, South Fork Coal Bank Creek, and Boxelder Creek in Fallon County

Several of these waterbodies would be crossed more than once. The waterbodies crossed by the proposed Project that have state water quality classification are presented in Table 3.3.1.2-1.

TABLE 3.3.1.2-1
Sensitive or Protected Waterbodies in Montana Crossed More than Once

Waterbody Name	Type	Number of Crossings
Corral Coulee	Intermittent	2
Cherry Creek	Intermittent	3
Foss Creek	Intermittent	3
Lone Tree Creek	Intermittent/Ephemeral[a]	2
Middle Fork Prairie Elk Creek	Ephemeral	2
Bear Creek	Intermittent/Ephemeral[a]	3
Shade Creek	Intermittent	3
Flying V Creek	Intermittent/Ephemeral[a]	2
Buffalo Springs Creek	Perennial/Intermittent[a]	2
Soda Creek	Intermittent	2

[a] In some cases, the stream type may change between crossings.

Impaired or Contaminated Waterbodies

Contamination has been documented in 11 sensitive or protected waterbodies in Montana (Appendix J). Contamination in these waterbodies includes unacceptable levels of at least one of the following parameters: iron, fecal coliform, lead, mercury, phosphorous, total kjeldahl nitrogen (TKN), dissolved oxygen, total dissolved solids, nitrate/nitrite. Impairments in these waterbodies include fish-passage barriers, sedimentation/siltation, alteration in stream-side or littoral vegetative cover, Chlorophyll-a, dissolved oxygen, low flow alteration, and physical substrate habitat alteration (see Table 3.3.1.2-2).

TABLE 3.3.1.2-2 Impaired or Contaminated Waterbodies in Montana	
Waterbody Name	**Impairment or Contamination**
Frenchman Creek	Alteration in stream-side or littoral vegetative cover; Chlorophyll-a; Low flow alterations
Buggy Creek	Iron
Cherry Creek	Iron
Milk River	Fecal Coliform; Lead; Mercury
Missouri River	Alteration in stream-side or littoral vegetative cover; Other flow regime alterations; Temperature, water
Middle Fork Prairie Elk Creek	Alteration in stream-side or littoral vegetative cover; Phosphorus (Total); Physical substrate habitat alterations; Total Kjehidahl Nitrogen (TKN)
East Fork Prairie Elk Creek	Alteration in stream-side or littoral vegetative cover; Phosphorus (Total); Physical substrate habitat alterations; TKN
Yellowstone River	Fish-passage barrier
Cabin Creek	Oxygen, Dissolved; Sedimentation/Siltation; TKN
Pennel Creek	Total Dissolved Solids
Sandstone Creek	Nitrate/Nitrite (Nitrite + Nitrate as N); TKN

Water Supplies

Along the proposed ROW in Montana, municipal water supplies are largely obtained from groundwater sources and are described in Section 3.3.1.1. The proposed ROW would pass within 1 mile downstream of the Cornwell Reservoir (currently breached) at MP 59 and within 1 mile of the Haynie Reservoir at MP 134. These reservoirs, when functional, are used for irrigation and stock watering.

Major waterbodies and reservoirs located within 10 miles downstream of proposed water crossings include Lester Reservoir, Frenchman Reservoir, Reservoir Number Four, Fort Peck Lake, North Dam, Christenson Reservoir, Lindsay Reservoir, Red Butte Dam, and three unnamed reservoirs. The approximate mileposts of these waterbodies and their associated pipeline stream crossings are presented in Appendix E. Wetlands areas are addressed in Section 3.4.

South Dakota

Waterbodies Crossed

As presented in Appendix E, 293 waterbody crossings would occur in South Dakota along the proposed Project route. Of the 293 crossings 20 are perennial streams, 95 are intermittent streams, 171 are ephemeral streams, 2 are natural ponds, and 5 are man-made ponds. Based on stream width, adjacent topography, adjacent infrastructure, and sensitive environmental areas, three rivers in South Dakota would be crossed using HDD method. These rivers include:

- Little Missouri River in Harding County (approximately 125 feet wide, MP 292);
- Cheyenne River in Meade and Haakon County (approximately 1,125 feet wide, MP 426); and
- White River in Lyman County (approximately 500 feet wide, MP 537).

The remaining 290 waterbodies would be crossed using one of several non-HDD methods described in the CMR Plan (Appendix B). The crossing method for each waterbody would be depicted on construction drawings but would ultimately be determined based on site-specific conditions at the time of crossing. Reclamation water pipeline crossings would include one in Haakon County near MP 467 and one in Jones County near MP 510 (see Figure 2.1-2). For these two crossings, Keystone would apply general design requirements consistent with Reclamation facility crossing criteria (see Appendix E).

Sensitive or Protected Waterbodies

The following streams and rivers that would be crossed by the proposed Project route in South Dakota contain state water quality designations or use designations (Appendix E). These waterbodies include:

- Little Missouri River, South Fork Grand River, and Clark's Fork Creek in Harding County;
- North Fork Moreau River in Butte County;
- South Fork Moreau River in Perkins County;
- Sulfur Creek, and Red Owl Creek in Meade County;
- Cheyenne River in Pennington County;
- Bad River in Haakon County;
- Williams Creek in Jones County; and
- White River in Lyman County.

In addition, all streams in South Dakota are assigned the beneficial uses of irrigation and fish and wildlife propagation, recreation, and stock watering (SDDENR 2008).

Impaired or Contaminated Waterbodies

Contamination has been documented in five of these sensitive or protected waterbodies in South Dakota (Keystone 2008) (Appendix J). Contamination or impairment in these waterbodies includes unacceptable levels of at least one of the following parameters: total suspended solids (TSS), salinity, specific conductance, and fecal coliform.

TABLE 3.3.1.2-3
Impaired or Contaminated Waterbodies in South Dakota

Waterbody Name	Impairment or Contamination
South Fork Grand River	Total Suspended Solids, Salinity
South Fork Moreau River	Specific Conductance
Cheyenne River	Total Suspended Solids, Fecal Coliform
White River	Total Suspended Solids, Fecal Coliform
Ponca Creek	Total Suspended Solids, Fecal Coliform

Water Supplies

Along the proposed ROW in South Dakota, municipal water supplies are largely obtained from groundwater sources and are described in Section 3.3.1.1. The proposed ROW would pass within 1 mile of the Wilson Lake Reservoir at MP 415.

Major waterbodies and reservoirs located within 10 miles downstream of proposed water crossings include Lake Gardner and five unnamed reservoirs. The approximate mileposts of these waterbodies and their associated pipeline stream crossings are presented in Appendix E.

Nebraska

Waterbodies Crossed

As presented in Appendix E, 157 waterbody crossings would occur in Nebraska along the proposed Project route. Of the 157 crossings 28 are perennial streams, 53 are intermittent streams, 66 are ephemeral streams, 8 are canals, 1 is a natural pond, and 1 is a man-made pond. Based on stream width, adjacent topography, adjacent infrastructure, and sensitive environmental areas, four rivers in Nebraska would be crossed using the HDD method. These rivers include:

- Niobrara River in Keya Paha and Rock County (approximately 1,300 feet wide, MP 615.5);
- Cedar River in Wheeler County (approximately 100 feet wide, MP 697);
- Loup River in Nance County (approximately 900 feet wide, MP 741); and
- Platte River in Merrick County (approximately 1,000 feet wide, MP 756).

The remaining 153 waterbodies would be crossed using one of several non-HDD methods described in the CMR Plan (Appendix B). The crossing method for each waterbody would be depicted on construction drawings but would ultimately be determined based on site-specific conditions at the time of crossing. One Reclamation canal crossing would occur in Nance County near MP 738 (see Figure 2.1-3). For this crossing, Keystone would apply general design requirements consistent with Reclamation facility crossing criteria (see Appendix E).

Sensitive or Protected Waterbodies

The following streams and rivers that would be crossed by the proposed Project route in Nebraska contain state water quality designations or use designations (Appendix E). Several of these waterbodies would be crossed more than once. These waterbodies include:

- Keya Paha River, Niobrara River, and Spring Creek in Keya Paha County;
- Ash Creek in Rock County;
- North Branch Elkhorn River, South Fork Elkhorn River, Elkhorn River, Holt Creek, and Dry Creek in Holt County;
- Cedar River in Wheeler County;
- South Branch Timber Creek and Loup River in Nance County;
- Prairie Creek, Side Channel Platte River, and Platte River in Merrick County;
- Big Blue River, Lincoln Creek, Beaver Creek, and West Fork Big Blue River in York County;
- Turkey Creek in Fillmore County; and
- South Fork Swan Creek and Cub Creek in Jefferson County.

Impaired or Contaminated Waterbodies

Contamination has been documented in five of these sensitive or protected waterbodies in Nebraska (Appendix J). Contamination or impairment in these waterbodies includes unacceptable levels of at least one of the following parameters: *E. coli*, low dissolved oxygen, and atrazine.

TABLE 3.3.1.2-4
Impaired or Contaminated Waterbodies in Nebraska

Waterbody Name	Impairment or Contamination
Keya Paha River	E. coli
Niobrara River	E. coli
Loup River	E. coli
Prairie Creek	Low Dissolved Oxygen
Big Blue River	Low Dissolved Oxygen, May-June atrazine

Water Supplies

Along the proposed ROW in Nebraska, municipal water supplies are largely obtained from groundwater sources and are described in Section 3.3.1.1.

Major waterbodies and reservoirs located within 10 miles downstream of proposed water crossings include Atkinson Reservoir, Chain Lake, Rush Lake, Sininger Lagoon, County Line Marsh, Cub Creek Reservoir 13-C, Cub Lake Reservoir 14-C, Big Indian Creek Reservoir 10-A, Big Indian Creek Reservoir 8-E, an unnamed lake, and four unnamed reservoirs. The approximate mileposts of these waterbodies and their associated pipeline stream crossings are presented in Appendix E.

Kansas

Construction planned in Kansas as part of the proposed Project comprises two new pump stations and appurtenant facilities, including transmission lines and access roads located in Clay and Butler counties at MP 49.7 and MP, 144.6, respectively. There are no expected impacts to surface water resources associated with these activities in Kansas.

Oklahoma

Waterbodies Crossed

As presented in Appendix E, 315 waterbody crossings would occur in Oklahoma along the proposed Project route. Of the 315 crossings, 69 are perennial streams, 111 are intermittent streams, 112 are ephemeral streams, 8 are seasonal, and 15 are unclassified. Based on stream width, adjacent topography, adjacent infrastructure, and sensitive environmental areas, seven rivers in Oklahoma would be crossed using the HDD method. These rivers include:

- Deep Fork in Creek County (approximately 125 feet wide, MP 22);
- North Canadian River in Okfuskee and Seminole County (approximately 250 feet wide, MP 39);
- Little River in Hughes County (approximately 110 feet wide, MP 70);

- Canadian River in Hughes County (approximately 700 feet wide, MP 74);
- Fronterhouse Creek (with a RR and road crossing, MP 122.6);
- Clear Boggy Creek in Atoka County (approximately 80 feet wide, MP 127); and
- Red River in Bryan County, OK and Fannin County TX (approximately 750 feet wide, MP 156).

The remaining 308 waterbodies would be crossed using one of several non-HDD methods described in the CMR Plan (Appendix B). The crossing method for each waterbody would be depicted on construction drawings but would ultimately be determined based on site-specific conditions at the time of crossing.

Sensitive or Protected Waterbodies

The following streams and rivers that would be crossed by the proposed Project route in Oklahoma contain state water quality designations or use designations (Appendix E). These waterbodies include:

- Red River in Bryan County;
- Bird Creek and Little River in Hughes County;
- Euchee Creek in Lincoln County;
- Little Hilliby Creek in Okfuskee County; and
- Sand Creek, Wewoka Creek, Little Wewoka Creek, and North Canadian River in Seminole County.

Impaired or Contaminated Waterbodies

Contamination has been documented in six of these sensitive or protected waterbodies in Oklahoma (Appendix J). Contamination in these waterbodies includes unacceptable levels of at least one of the following parameters: chloride, Fish bioassessments, TDS, *Enterococcus* spp, *E. coli*, and lead. Impairments in these waterbodies include turbidity and dissolved oxygen.

TABLE 3.3.1.2-5
Impaired or Contaminated Waterbodies in Oklahoma

Waterbody Name	Impairment or Contamination
Canadian River	Enterococcus Bacteria, Lead, Total Dissolved Solids, Turbidity
Euchee Creek	Eschericihia coli, Enterococcus bacteria, Turbidity
Hilliby Creek	Fish bioassessments
Little River	Enterococcus bacteria, Lead, Turbidity
Little Wewoka Creek	Dissolved Oxygen
Sand Creek	Chloride, Total Dissolved Solids

Water Supplies

Along the proposed ROW in Oklahoma, municipal water supplies are largely obtained from groundwater sources and are described in Section 3.3.1.1.

Major waterbodies and reservoirs located within 10 miles downstream of proposed water crossings include Stroud Lake. The approximate milepost of this waterbody and its associated pipeline stream crossings is presented in Appendix E.

Texas

Waterbodies Crossed

As presented in Appendix E, 631 waterbody crossings would occur in Texas along the proposed Gulf Coast Segment route, and 20 waterbody crossings would occur along the proposed Houston Lateral route. Of the 631 crossings on the Gulf Coast Segment, 176 are perennial streams, 189 are intermittent streams, 223 are ephemeral streams, 5 are seasonal, and 38 are unclassified. Of the 20 crossings on the Houston Lateral, 5 are perennial streams, 2 are intermittent streams, 8 are ephemeral streams, 2 are artificial path (an artificial path is any man-made or modified flow path), and 3 are canal/ditch. Based on stream width, adjacent topography, adjacent infrastructure, and sensitive environmental areas, 19 waterbodies on the proposed Gulf Coast Segment and 4 waterbodies on the proposed Houston Lateral route would be crossed using the HDD method. These waterbodies include:

Gulf Coast Segment

- Red River in Bryan County, OK and Fannin County TX (approximately 750 feet wide, MP 156);
- Bois d'Arc Creek in Fannin and Lamar counties (approximately 125 feet wide, MP 162);
- North Sulphur River in Lamar and Delta counties (approximately 350 feet wide, MP 191);
- South Sulphur River in Delta and Hopkins counties (approximately 100 feet wide, MP 202);
- White Oak Creek in Hopkins County (approximately 300 feet wide, MP 213);
- Big Cyprus Creek in Franklin County (approximately 75 feet wide, MP 228);
- Private lake in Wood County (approximately 250 feet wide, MP 255);
- Big Sandy Creek in Upshur County (approximately 180 feet wide, MP 257);
- Sabine River in Upshur and Smith counties (approximately 175 feet wide, MP 264);
- East Fork Angelina River in Rusk County (approximately 50 feet wide, MP 313);
- Angelina River in Nacogdoches and Cherokee counties (approximately 80 feet wide, MP 334);
- Neches River in Angelina and Polk counties (approximately 150 feet wide, MP 369);
- Menard Creek in Liberty County (approximately 50 feet wide, MP 416);
- Pine Island Bayou in Hardin County (MP 449);
- Neches Valley Canal Authority (approximately 150 feet wide, MP 462);
- Lower Neches Valley Canal Authority in Jefferson County (approximately 150 feet wide, MP 463);
- Willow Marsh Bayou in Jefferson County (approximately 280 feet wide , MP 470);
- Canal crossing in Jefferson County (MP 471); and
- Hillebrandt Bayou in Jefferson County (approximately 490 feet wide, MP 474).

Houston Lateral Segment

- Trinity Creek Marsh in Liberty County (MP 18);
- Trinity River in Liberty County (MP 23);
- Cedar Bayou in Harris County (MP 36); and
- San Jacinto River in Harris County (MP 43).

The remaining 612 waterbodies on the Gulf Coast Segment and 16 waterbodies on the Houston Lateral would be crossed using one of several non-HDD methods described in the CMR Plan (Appendix B). The crossing method for each waterbody would be depicted on construction drawings but would ultimately be determined based on site-specific conditions at the time of crossing.

Sensitive or Protected Waterbodies

The following streams and rivers that would be crossed by the proposed Project route in Texas contain state water quality designations or use designations (Appendix E). Several of these waterbodies would be crossed more than once. These waterbodies include:

Gulf Coast Segment

- Big Sandy Creek in Wood County;
- Big Sandy Creek in Upshur County;
- Angelina River in Cherokee County;
- Angelina River and East Fork Angelina River in Rusk County;
- Angelina River in Nacogdoches County;
- Pine Island Bayou in Hardin County;
- Neches River, Piney Creek, and Big Sandy Creek in Polk County; and
- Hillebrandt Bayou in Jefferson County.

Impaired or Contaminated Waterbodies

Contamination has been documented in 3 of these sensitive or protected waterbodies in Texas (Appendix J). Contamination in these waterbodies includes unacceptable levels of at least one of the following parameters: bacteria, low dissolved oxygen, and lead.

TABLE 3.3.1.2-6 Impaired or Contaminated Waterbodies in Texas	
Waterbody Name	**Impairment or Contamination**
Angelina River above Sam Rayburn Reservoir	Bacteria
Big Sandy Creek	Bacteria
East Fork Angelina River	Bacteria, Lead
Hillebrandt Bayou	Dissolved Oxygen
Hurricane Creek	Bacteria
Jack Creek	Bacteria
Neches River below Lake Palestine	Bacteria, lead
Pine Island bayou	Dissolved Oxygen
Piney Creek	Bacteria, Dissolved Oxygen
Willow Creek	Dissolved Oxygen
Cedar Bayou above Tidal	Bacteria, Benthic Macroinvertebrates
San Jacinto River above Tidal	Dioxin, PCB's

Water Supplies

Along the proposed ROW in Texas, municipal water supplies are largely obtained from groundwater sources and are described in Section 3.3.1.1.

Major waterbodies and reservoirs located within 10 miles downstream of proposed water crossings for the Gulf Coast Segment and the Houston Lateral include Pat Mayse Lake/WMA, proposed George Parkhouse Reservoir, Lake Cypress Springs, Lake Bob Sandlin, proposed Little Cypress Reservoir, Lake Greenbriar, Prairie Creek Reservoir, Lake Tyler, proposed Lake Columbia, Lake Striker, Drainage in David Crockett National Forest, Fiberboard Lake, Drainage in Big Thicket National Preserve, Drainage in Trinity River National Wildlife Refuge, Daisetta Swamp, drainage in Big Thicket National Preserve, Drainage in J.D. Murphree WMA, Highlands Reservoir, George White Lake, and McCracken Lake. The approximate mileposts of these waterbodies and drainage areas and their associated pipeline stream crossings are presented in Appendix E.

3.3.1.3 Floodplains

Floodplains are relatively low, flat areas of land that surround some rivers and streams and convey overflows during flood events. Floodwater energy is dissipated as flows spread out over a floodplain, and significant storage of floodwaters can occur through infiltration and surficial storage in localized depressions on a floodplain. Floodplains form where overbank floodwaters spread out laterally and deposit fine-grained sediments. The combination of rich soils, proximity to water, riparian forests, and the dynamic reworking of sediments during floods creates a diverse landscape with high habitat quality. Floodplains typically support a complex mosaic of wetland, riparian, and woodland habitats that are spatially and temporally dynamic.

Changing climatic and land use patterns in much of the west-central United States has resulted in region-wide incision of many stream systems. Stream systems cutting channels deeper into the surrounding floodplain cause high floodplain terraces to form along valley margins. These floodplain terraces are common along the proposed Project route and receive floodwaters less frequently than the low floodplains adjacent to the streams.

From a policy perspective, the Federal Emergency Management Agency (FEMA) defines a floodplain as being any land area susceptible to being inundated by waters from any source (FEMA 2005). FEMA prepares Flood Insurance Rate Maps that delineate flood hazard areas, such as floodplains, for communities. These maps are used to administer floodplain regulations and to reduce flood damage. Typically, these maps indicate the locations of 100-year floodplains, which are areas with a 1-percent chance of flooding occurring in any single year.

Executive Order 11988, Floodplain Management, states that actions by federal agencies are to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplain development wherever there is a practicable alternative. Each agency is to provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for:

- Acquiring, managing, and disposing of federal lands, and facilities;
- Providing federally undertaken, financed, or assisted construction and improvements; and
- Conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

Designated floodplains crossed by the proposed route are listed in Table 3.3.1.3-1.

TABLE 3.3.1.3-1
Designated Floodplain Areas Crossed by the Proposed Pipeline Route

Location	Approximate Mileposts	Watercourse Associated with Floodplain
Steele City Segment		
Montana		
Valley	81.2 - 84.2	Milk River
Valley/McCone	87.2 - 89.2	Missouri River
Valley/McCone	89.2 - 89.2	Missouri River
Valley/McCone	89.2 - 89.3	Missouri River
Valley/McCone	89.3 - 89.5	Missouri River
McCone	146.4 - 147.4	Redwater River
Dawson	193.4 - 196.4	Yellowstone River
South Dakota		
Harding	291 - 292	Little Missouri River
Meade/Pennington	424.1 - 425.9	Cheyenne River
Meade/Pennington	425.9 - 426.2	Cheyenne River
Haakon	480.2 - 482.4	Bad River
Lyman/ Tripp	536.8 - 537.1	White River
Lyman/ Tripp	537.1 - 538.5	White River
Nebraska		
Keya Paha	599.8 - 600.1	Keya Paha River
Keya Paha/ Rock	615.3 - 615.6	Niobrara River

TABLE 3.3.1.3-1
Designated Floodplain Areas Crossed by the Proposed Pipeline Route

Location	Approximate Mileposts	Watercourse Associated with Floodplain
Keya Paha/ Rock	615.6 - 615.8	Niobrara River
Wheeler	697.2 - 697.2	Cedar River
Wheeler	697.2 - 697.3	Cedar River
Wheeler	697.6 - 697.7	Cedar River
Nance	739 - 742.8	Loup River
Merrick	742.8 - 746.2	Loup River
Merrick	747.1 - 747.6	Prairie Creek
Merrick	750.6 - 752.5	Silver Creek
Merrick	753.8 - 754.2	Silver Creek
Merrick	755.6 - 756.7	Platte River
Merrick	757.4 - 757.6	Platte River
Merrick/ Hamilton	758 - 758.3	Platte River
Merrick/ Hamilton	758.3 - 758.5	Platte River
York	765.5 - 765.5	Big Blue River
York	767 - 767.1	Big Blue River
York	774.7 - 775	Lincoln Creek
York	778 - 778	Beaver Creek
York	778 - 780.1	Beaver Creek
York	780.1 - 780.3	Beaver Creek
York	786.1 - 786.1	West Fork Big Blue River
York	786.2 - 786.2	West Fork Big Blue River
York	787.3 - 787.3	West Fork Big Blue River
York	789.4 - 790	West Fork Big Blue River
Fillmore	795 - 795.1	Indian Creek
Fillmore	804.4 - 804.5	Turkey Creek
Fillmore	807.5 - 807.6	Turkey Creek
Fillmore	808.1 - 808.6	Turkey Creek
Saline	810 - 810.1	Turkey Creek
Jefferson	826.2 - 826.3	South Fork Swan Creek
Jefferson	828.3 - 828.4	Swan Creek
Jefferson	829.4 - 829.5	Swan Creek
Jefferson	835.1 - 835.3	Cub Creek
Jefferson	836.3 - 836.4	Cub Creek
Jefferson	836.5 - 836.5	Cub Creek
Jefferson	836.8 - 836.9	Cub Creek
Jefferson	844.9 - 845.1	Big Indian Creek
Jefferson	847.3 - 847.4	Big Indian Creek

TABLE 3.3.1.3-1
Designated Floodplain Areas Crossed by the Proposed Pipeline Route

Location	Approximate Mileposts	Watercourse Associated with Floodplain
Gulf Coast Segment		
Oklahoma		
Lincoln	1 - 1.3	Wildhorse Creek
Lincoln	2.4 - 2.5	Turkey Creek
Lincoln	3.2 - 3.5	Euchee Creek
Lincoln	13.9 - 14.1	Lilly Creek
Creek	19.4 - 19.6	Deep Fork River
Creek	21.3 - 21.5	Deep Fork River
Creek	21.6 - 21.8	Deep Fork River
Creek	21.9 - 23	Deep Fork River
Seminole	38.6 - 38.8	North Canadian River
Seminole	43 - 43.1	Sand Creek
Seminole	43.3 - 43.6	Sand Creek
Seminole	47.9 - 48	Little Wewoka Creek
Seminole	50.1 - 50.2	Little Wewoka Creek
Seminole	57.9 - 59	Wewoka Creek
Hughes	59.6 - 59.7	Jacobs Creek
Hughes	59.8 - 59.9	Jacobs Creek
Hughes	60.2 - 60.6	Jacobs Creek
Hughes	60.7 - 60.8	Jacobs Creek
Hughes	64.7 - 64.9	Bird Creek
Hughes	65.2 - 65.3	Bird Creek
Hughes	65.5 - 65.7	Bird Creek
Hughes	65.9 - 66.1	Bird Creek
Hughes	66.3 - 67.4	Bird Creek
Hughes	68.9 - 69	Little River
Hughes	69.2 - 69.4	Little River
Hughes	69.7 - 70.4	Little River
Hughes	74 - 75	Canadian River
Hughes	86.4 - 86.5	Muddy Boggy Creek
Hughes/Coal	86.7 - 86.7	Muddy Boggy Creek
Coal	86.7 - 87.6	Muddy Boggy Creek
Coal	87.8 - 87.8	Muddy Boggy Creek
Atoka	114.7 - 115.2	French Henry Creek
Atoka	122.6 - 122.7	Fronterhouse Creek
Atoka	122.9 - 123	Fronterhouse Creek
Atoka	125.5 - 125.9	Fronterhouse Creek

TABLE 3.3.1.3-1
Designated Floodplain Areas Crossed by the Proposed Pipeline Route

Location	Approximate Mileposts	Watercourse Associated with Floodplain
Atoka	126.1 - 127.6	Clear Boggy Creek
Atoka	128.2 - 128.5	Clear Boggy Creek
Atoka	131.3 - 131.7	Cowpen Creek
Atoka	132.9 - 133	Long Branch
Bryan	135.4 - 135.5	Pine Creek
Bryan	155.6 - 155.8	Red River
Texas		
Fannin	155.8 - 160.9	Red River
Fannin	161.5 - 162	Bois d'Arc Creek
Lamar	162 - 162.1	Bois d'Arc Creek
Lamar	162.9 - 163.6	Bois d'Arc Creek
Lamar	166.1 - 166.2	Slough Creek
Lamar	169.2 - 169.5	Sanders Creek
Lamar	170.9 - 171.3	Sanders Creek
Lamar	172.6 - 172.8	Cottonwood Creek
Lamar	174.1 - 174.2	Doss Creek
Lamar	186.3 - 186.6	Mallory Creek
Lamar	187.3 - 187.8	Mallory Creek
Lamar	188.5 - 188.6	Mallory Creek
Lamar	189.2 - 189.4	Justiss Creek
Lamar/Delta	189.4 - 190.5	North Sulphur River
Lamar/Delta	190.7 - 190.8	North Sulphur River
Delta/Hopkins	201.7 - 202.6	Evans Branch
Hopkins	202.7 - 203.4	South Sulphur River
Hopkins	206.7 - 206.8	Wolfpen Creek
Hopkins	212.1 - 212.2	Crosstimber Creek
Hopkins	212.4 - 212.4	Crosstimber Creek
Hopkins	212.7 - 214	White Oak Creek
Hopkins	216.7 - 216.8	Stouts Creek
Hopkins	217 - 217.8	Stouts Creek
Hopkins	218.1 - 218.2	Stouts Creek
Hopkins	220.9 - 221	Greenwood Creek
Wood	234 - 234.2	Briary Creek
Wood	234.6 - 234.6	Briary Creek
Wood	235.5 - 235.6	Briary Creek
Wood	242 - 242.2	Little Cypress Creek
Wood	242.2 - 242.3	Little Cypress Creek

TABLE 3.3.1.3-1
Designated Floodplain Areas Crossed by the Proposed Pipeline Route

Location	Approximate Mileposts	Watercourse Associated with Floodplain
Wood	242.7 - 242.7	Little Cypress Creek
Wood	253 - 253.1	Blue Branch
Wood/Upshur	257.2 - 257.4	Big Sandy Creek
Wood/Upshur	257.4 - 257.5	Big Sandy Creek
Wood/Upshur	257.8 - 257.9	Big Sandy Creek
Upshur/Smith	263.5 - 263.7	Sabine River
Smith	268.8 - 269.1	Sabine River
Smith	277 - 277.1	Prairie Creek
Smith	277.3 - 277.4	Prairie Creek
Smith	277.7 - 277.7	Prairie Creek
Smith	278.4 - 278.6	Prairie Creek
Smith	278.7 - 279	Prairie Creek
Smith	280.7 - 280.8	Prairie Creek
Smith	282 - 282.1	Prairie Creek
Smith	283.4 - 283.6	Prairie Creek
Smith	287.5 - 287.6	Kickapoo Creek
Smith	290 - 290.2	Denton Creek
Smith	292.3 - 292.5	Denton Creek
Cherokee	297.6 - 297.7	Mill Creek
Cherokee	298.6 - 298.7	Bowles Creek
Cherokee	298.8 - 298.9	Bowles Creek
Cherokee	299.1 - 299.2	Bowles Creek
Cherokee	300.5 - 300.6	Bowles Creek
Cherokee/Rusk	300.7 - 300.9	Bowles Creek
Cherokee/Rusk	300.9 - 302.3	Bowles Creek
Rusk	303 - 303.1	Boggy Branch
Rusk	303.8 - 303.9	Boggy Branch
Rusk	308.1 - 308.7	Autry Branch
Rusk	309.2 - 309.3	Autry Branch
Rusk	310.8 - 310.8	Striker Creek
Rusk	311.4 - 314	East Fork Angelina River
Nacogdoches	316.6 - 316.9	Indian Creek
Nacogdoches	320.2 - 320.3	Beech Creek
Nacogdoches	320.7 - 320.8	Beech Creek
Nacogdoches	325.9 - 326.4	Yellow Bank Creek
Nacogdoches/Cherokee	334 - 334.1	Legg Creek
Nacogdoches/Cherokee	334.1 - 337.3	Legg Creek

TABLE 3.3.1.3-1
Designated Floodplain Areas Crossed by the Proposed Pipeline Route

Location	Approximate Mileposts	Watercourse Associated with Floodplain
Cherokee	338.4 - 338.6	Stokes Creek
Angelina	342.2 - 342.2	Red Bayou
Angelina	342.5 - 342.6	Red Bayou
Angelina	344.9 - 344.9	Watson Branch
Angelina	347.6 - 349	Red Bayou
Angelina	349 - 349.3	Neches River
Angelina	349.3 - 349.3	Neches River
Angelina	350.9 - 351.2	Buncombe Creek
Angelina	352 - 353.1	Crawford Creek
Angelina	353.1 - 353.2	Crawford Creek
Angelina	353.2 - 353.5	Crawford Creek
Angelina	358.8 - 358.9	Neches River
Angelina	359.2 - 359.2	Neches River
Angelina	360.4 - 361.6	Hurricane Creek
Angelina	362.8 - 362.9	Neches River
Angelina	363.1 - 363.2	Neches River
Angelina	363.5 - 364.7	Neches River
Angelina	366 - 367	White Oak Creek
Angelina/Polk	367.9 - 368.5	White Oak Creek
Angelina/Polk	368.5 - 369.1	Neches River
Polk	369.1 - 369.8	Neches River
Polk	375.7 - 375.7	Piney Creek
Polk	375.8 - 375.9	Piney Creek
Polk	376.2 - 376.7	Piney Creek
Polk	377.2 - 377.2	Piney Creek
Polk	377.2 - 377.4	Piney Creek
Polk	377.4 - 377.9	Bear Creek
Polk	378 - 378	Bear Creek
Polk	382.6 - 382.7	Kennedy Creek
Polk	382.8 - 383	Kennedy Creek
Polk	384.5 - 384.6	Johnson Creek
Polk	389.8 - 389.9	Big Sandy Creek
Polk	391.7 - 391.9	Big Sandy Creek
Polk	393 - 393.1	Big Sandy Creek
Polk	397.2 - 397.4	Menard Creek
Polk	404.2 - 404.7	Menard Creek
Polk	407 - 407.2	Dry Branch

TABLE 3.3.1.3-1
Designated Floodplain Areas Crossed by the Proposed Pipeline Route

Location	Approximate Mileposts	Watercourse Associated with Floodplain
Liberty	416.2 - 416.3	Menard Creek
Liberty	416.3 - 416.3	Menard Creek
Liberty	416.3 - 416.4	Menard Creek
Liberty	434.7 - 436.1	Batiste Creek
Liberty	439.2 - 439.6	Mayhaw Creek
Liberty	439.6 - 439.6	Mayhaw Creek
Liberty/Hardin	439.6 - 440	Mayhaw Creek
Hardin	440.6 - 441	Mayhaw Creek
Hardin	441.3 - 441.5	Mayhaw Creek
Hardin	448.9 - 449.2	Pine Island Bayou
Hardin	449.2 - 449.5	Pine Island Bayou
Hardin	449.5 - 449.9	Pine Island Bayou
Hardin	449.9 - 450.4	Pine Island Bayou
Hardin/Liberty	451.1 - 451.3	Pine Island Bayou
Hardin/Liberty	451.3 - 451.4	Pine Island Bayou
Hardin/Liberty	451.4 - 451.5	Pine Island Bayou
Hardin/Liberty	451.5 - 451.9	Pine Island Bayou
Liberty/Jefferson	451.9 - 451.9	Pine Island Bayou
Liberty/Jefferson	451.9 - 452	Pine Island Bayou
Liberty/Jefferson	452 - 452.1	Pine Island Bayou
Jefferson	453.3 - 454.4	Pine Island Bayou
Jefferson	457.8 - 458.3	Cotton Creek
Jefferson	465.1 - 465.3	Willow Marsh Bayou
Jefferson	465.7 - 465.9	Willow Marsh Bayou
Jefferson	468.1 - 468.2	Willow Marsh Bayou
Jefferson	468.3 - 468.7	Willow Marsh Bayou
Jefferson	469.5 - 470	Willow Marsh Bayou
Jefferson	470 - 471.4	Willow Marsh Bayou
Jefferson	471.4 - 473.1	Willow Marsh Bayou
Jefferson	473.5 - 474	Willow Marsh Bayou
Jefferson	474.5 - 475.3	Willow Marsh Bayou
Jefferson	482.4 - 482.6	Neches River

Sources: Interpretation of USGS 1:24,000 Topographic Maps and PHMSA (http://www.npms.phmsa.dot.gov); FEMA 100-year floodplain maps.

In the Gulf Coast Segment, pump station 32 at MP 0.0 in Lincoln County, Oklahoma and pump station 41 at MP 435.15 in Liberty County, Texas are situated within 100-year floodplains as designated by FEMA.

As proposed, the Project has 10 MLVs in the 100-year floodplain (Table 3.3.1.3-2). However, MLV locations may change during final design or in response to PHMSA conditions.

TABLE 3.3.1.3-2
Proposed Mainline Valve Locations within Designated 100-Year Floodplains

County	MLV	Approximate Milepost	Watercourse Associated with Floodplain
Steele City Segment			
Montana			
Valley	260-VLLEY-03A-B0-MLV-01	81.4	Milk River
Valley	260-VLLEY-04A-B0-MLV-01	84.4	Milk River
Dawson	260-CRCLE-02A-B0-MLV-01	194.4	Yellowstone River
Nebraska			
Merrick	260-ERSCN-03A-B0-MLV-01	747.5	Prairie Creek
Gulf Coast Segment			
Oklahoma			
Hughes	290-CRMWL-01A-B0-MLV-01	66.6	Bird Creek
Texas			
Jefferson	290-LIBRT-04A-B0-MLV-01	472.5	Willow Marsh Bayou
Houston Lateral			
Texas			
Liberty	MLV-305	21.75	Trinity River
Harris	MLV-320	42.92	San Jacinto River
Harris	CK-MLV-325	44.38	San Jacinto River
Harris	MLV-330	48.57	San Jacinto River

The southeast portion of the proposed Cushing tank farm in Lincoln County, Oklahoma, would also lie within the 100-year floodplain of Wildhorse Creek.

3.3.2 Potential Impacts

3.3.2.1 Groundwater

Construction Impacts

Potential impacts to groundwater during construction activities would include:

- Temporary to long-term surface water quality degradation during or after construction from disposal of materials and equipment;
- Temporary increases in TSS concentrations where the water table is disturbed during trenching and excavation activities (drawdown of the aquifer is possible where dewatering is necessary);

- Increased surface water runoff and erosion from clearing vegetation in the ROW; and
- Degradation of groundwater quality due to potential blasting.

Shallow or near-surface aquifers are present beneath the proposed route (see Table 3.3.1-2 and Figures 3.3.1-1 through 3.3.1-5). Shallow aquifers could be impacted by construction activities. Many of these shallow or near-surface aquifers occur along alluvial stream valleys. In Montana, many shallow aquifers present in the subsurface beneath the proposed route are isolated by the presence of overlying glacial till or other confining units.

Construction impacts to groundwater resources associated with hazardous liquids spills and leaks are discussed in Section 3.13.

TSS Concentrations

Although there is potential for dewatering of shallow groundwater aquifers and potential changes in groundwater quality (such as increases in TSS concentrations) during trenching and excavation activities, these changes are expected to be temporary. Shallow groundwater aquifers generally recharge quickly because they are receptive to recharge from precipitation and surface water flow.

Runoff, Erosion, and Dust Control

Implementation of measures described in the proposed Project CMR Plan (Appendix B) would reduce erosion (Section 3.2.2.1) and control surface water runoff during vegetation clearing in the ROW. However infiltration to groundwater will ultimately be reduced due to vegetation clearing in the ROW. Groundwater or surface water resources may be needed to control dust during construction activities.

Hydrostatic Testing

Groundwater withdrawal for hydrostatic testing may be necessary at certain locations where surface water sources cannot be used. Infiltration of hydrostatic testing waters would temporarily increase local groundwater levels; however, the duration of increase would be minimal. Hydrostatic test water will be tested and discharged in accordance with state or federal permits. All applicable water withdrawal and discharge permits would be acquired prior to hydrostatic testing.

Operations Impacts

Routine operation and maintenance is not expected to affect groundwater resources.

Operational impacts to groundwater resources associated with hazardous liquids spills and leaks are discussed in Section 3.13.

3.3.2.2 Surface Water

Construction Impacts

Potential impacts on surface water resources during construction activities would include:

- Temporary increases in TSS concentrations and increased sedimentation during stream crossings;
- Temporary to short-term degradation of aquatic habitat from in-stream construction activities;
- Changes in channel morphology and stability caused by channel and bank modifications;

- Temporary to long-term decrease in bank stability and resultant increase in TSS concentrations from bank erosion as vegetation removed from banks during construction is re-establishing; and
- Temporary reduced flow in streams and potential other adverse effects during hydrostatic testing activities.

Construction impacts to surface water resources associated with hazardous liquids spills and leaks are discussed in Section 3.13.

Stream Crossings and In-Stream Construction Activities

Depending on the type of stream crossing, one of six construction methods would be used: the non-flowing open-cut method, the flowing open-cut method, the dry flume method, the dry dam-and-pump method, the HDD method, or the horizontal bore crossing method. More detailed descriptions of each crossing method and measures to reduce impacts associated with each method are provided in the CMR Plan (Appendix B) and in the Project Description (Section 2.0). Each stream crossing and chosen method would be shown on construction drawings but may be amended or changed based on site-specific conditions during construction. Open-cut methods would be used at most crossings, unless deemed not feasible due to site conditions during construction or to protect sensitive waterbodies, as determined by the appropriate regulatory authority. At 39 major and sensitive waterbody crossings the HDD method would be used. The river crossing procedures and measures to reduce impacts included in the CMR Plan (Appendix B) would be implemented. For waterbody crossings where HDD would be used, disturbance to the channel bed and banks would be avoided, however measures identified in a frac-out plan would be implemented as needed in the instance of a frac-out.

Where the HDD method is not used for major waterbody crossings or for waterbody crossings where important fisheries resources could be impacted, a site-specific plan addressing proposed additional construction and impact reduction procedures would be developed (CMR Plan, Appendix B). Prior to commencing any stream crossing construction activities, permits would be required under Section 404 of the Clean Water Act (CWA) through the USACE and Section 401 water quality certification as per state regulations and these agencies could require measures to limit unnecessary impacts such as requiring all the non-HDD crossings to be done during dry conditions.

Construction activities for open-cut wet crossings involve excavation of the channel and banks. Construction equipment and excavated soils would be in direct contact with surface water flow. The degree of impact from construction activities would depend on flow conditions, stream channel conditions, and sediment characteristics. For the types of crossings listed below, the following measures would be implemented on a site-specific basis:

- **Contaminated or Impaired Waters.** If required, specific crossing and sediment handling procedures would be developed with the appropriate regulatory agencies and agency consultation and recommendations would be documented.
- **Sensitive/Protected Waterbodies.** If required, specific construction and crossing methods would be developed in conjunction with USACE and U.S. Fish and Wildlife Service (USFWS) consultation. The appropriate method of crossing these waterbodies would be determined by USACE or USFWS, as applicable.
- **Frac-out Plan.** A plan would be developed in consultation with the regulatory agencies to address appropriate response and crossing implementation in the event of a frac out during HDD crossings.

Implementation of measures as described in the proposed Project CMR Plan (Appendix B) and additional conditions from permitting agencies would reduce adverse impacts resulting from open-cut wet crossings. All contractors would be required to follow the identified procedures to limit erosion and other land disturbances. The CMR Plan describes the use of buffer strips, drainage diversion structures, sediment barrier installations, and clearing limits, as well as procedures for waterbody restoration at crossings. (See Section 2.0 and the CMR Plan for a discussion of the proposed waterbody crossing methods.)

For construction access, temporary bridges, including subsoil fill over culverts, timber mats supported by flumes, railcar flatbeds, and flexi-float apparatus would be installed across waterbodies. These temporary crossings would be designed and located to minimize damage to stream banks and adjacent lands. The use of temporary crossings would reduce the impacts to the waterbodies by providing access for equipment to specific locations.

Following completion of waterbody crossings, waterbody banks would be restored to preconstruction contours, or at least to a stable slope. Stream banks would be seeded for stabilization, and mulched or covered with erosion control fabric in accordance with the CMR Plan and applicable state and federal permit conditions. Additional erosion control measures would be installed as specified in any permit requirements. However, erosion control measures can themselves cause adverse environmental impacts. For example, placement of rock along the bank at a crossing could induce bank failure further downstream. Geomorphic assessment of waterbody crossings could provide significant cost savings and environmental benefits. The implementation of appropriate measures to protect pipeline crossings from channel incision and channel migration can reduce the likelihood of washout-related emergencies, reduce maintenance frequency, limit adverse environmental impacts, and in some cases improve stream conditions.

Therefore, waterbody crossings would be assessed by qualified personnel in the design phase of the proposed Project with respect to the potential for channel aggradation/degradation and lateral channel migration. The level of assessment for each crossing could vary based on the professional judgment of the qualified design personnel. The pipeline would be installed as necessary to address any hazards identified by the assessment. The pipeline would be installed at the design crossing depth for at least 15 feet beyond the design lateral migration zone, as determined by qualified personnel. The design of the crossings also would include the specification of appropriate stabilization and restoration measures. Permits required under Sections 401 and 404 of the CWA would include additional site specific conditions as determined by USACE and appropriate state regulatory authorities.

Hydrostatic Testing

Water used for hydrostatic testing would be obtained from nearby surface water resources or municipal sources. These sources include streams, rivers, and privately owned reservoirs. There have been 50 potential surface water sources identified that could supply water for hydrostatic testing along the proposed project route depending on the flows at the time of testing and the sensitivity of the individual waterbodies for other uses (see CMR Plan, Appendix B). FERC has developed criteria for the minimum separation distance for hydrostatic test manifolds from wetlands and riparian areas appropriate for natural gas pipeline construction. Although the proposed Project is not subject to FERC authority, hydrostatic test manifolds would be located more than 100 feet away from wetlands and riparian areas to the maximum extent possible, consistent with FERC requirements.

During proposed Project construction, hydrostatic test water would not be withdrawn from any waterbody where such withdrawal would create adverse affects. All surface water resources utilized for hydrostatic testing would be approved by the appropriate permitting agencies prior to initiation of any testing activities. Planned withdrawal rates for each water resource would be evaluated and approved by these agencies prior to testing. No resource would be utilized for hydrostatic testing without receipt of applicable permits. As stated in the proposed Project CMR Plan (Appendix B), required water analyses would be obtained prior to any water filling and discharging operations associated with hydrostatic testing.

The water withdrawal methods described in the proposed Project CMR Plan (Appendix B) would be implemented and followed. These procedures include screening of intake hoses to prevent the entrainment of fish or debris, keeping the hose at least 1 foot off the bottom of the water resource, prohibiting the addition of chemicals into the test water, and avoiding discharging any water that contains visible oil or sheen following testing activities.

Hydrostatic test water would be discharged to the source water at an approved location along the waterway/wetland or to an upland area within the same drainage as the source water where it may evaporate or infiltrate. Discharged water would be tested to ensure it meets applicable water quality standards imposed by the discharge permits for the permitted discharge locations. The proposed Project CMR Plan incorporates additional measures designed to minimize the impact of hydrostatic test water discharge, including regulation of discharge rate, the use of energy dissipation devices, channel lining, and installation of sediment barriers as necessary (see Appendix B).

Operations Impacts

Channel migration or streambed degradation could potentially expose the pipeline, resulting in temporary short-term or long-term adverse impacts to water resources, however protective activities such as reburial or bank armoring would be implemented to reduce these impacts. As described in the proposed Project CMR Plan (Appendix B), a minimum depth of cover of 5 feet below the bottom of all waterbodies would be maintained for a distance of at least 15 feet to either side of the edge of the waterbody. General channel incision or localized headcutting could threaten to expose the pipeline during operations. In addition, channel incision could sufficiently increase bank heights to destabilize the slope, ultimately widening the stream. Sedimentation within a channel could also trigger lateral bank erosion, such as the expansion of a channel meander opposite a point bar. Bank erosion rates could exceed several meters per year. Not maintaining an adequate burial depth for pipelines in a zone that extends at least 15 feet (5 meters) beyond either side of the active stream channel may necessitate bank protection measures that would increase both maintenance costs and environmental impacts. Potential bank protection measures could include installing rock, wood, or other materials keyed into the bank to provide protection from further erosion, or regarding the banks to reduce the bank slope. Disturbance associated with these maintenance activities may potentially create additional water quality impacts.

All waterbody crossings would be assessed by qualified personnel in the design phase of the proposed Project with respect to the potential for channel aggradation/degradation and lateral channel migration. The level of assessment for each crossing could vary based on the professional judgment of the qualified design personnel. The pipeline would be installed as determined to be necessary to address any hazards identified by the assessment. The pipeline would be installed at the design crossing depth for at least 15 feet beyond the design lateral migration zone as determined by qualified personnel. The design of the crossings would also include the specification of appropriate stabilization and restoration measures

Operational impacts to surface water resources associated with hazardous liquids spills and leaks are discussed in Section 3.13.

In addition to the measures to protect water resources during operation specified in the CMR Plan (Appendix B), the water resource protection measures included in Appendices F, L, and P to the Environmental Specifications developed for the proposed Project by MDEQ would be implemented in

Montana. In South Dakota, the water protection conditions that were developed by the South Dakota Public Utility Commission (SDPUC) and attached to its Amended Final Decision and Order; Notice of Entry HP09-001 would be implemented.

3.3.2.3 Floodplains

The pipeline would be constructed under river channels with potential for lateral scour. In floodplain areas adjacent to waterbodies, the contours would be restored to as close to previously existing contours as practical and would revegetate the construction ROW in accordance with its CMR Plan (Appendix B). Therefore, after construction the pipeline would not obstruct flows over designated floodplains.

Although two pump stations and 6 MLVs would be in the 100-year floodplain as currently proposed, the effect of those facilities on floodplain function would be minor. These facilities would be constructed after consultation with the appropriate county agencies to design and to meet county requirements and to obtain the necessary permits associated with construction in the 100-year floodplain.

3.3.2.4 Potential Additional Mitigation Measures

Potential additional mitigation measures include the following:

- Taking into account the concerns expressed by EPA and other commenters on the draft and supplemental draft EIS, DOS in consultation with PHMSA and EPA, determined that it may be appropriate for the applicant to commission an additional engineering risk analysis of the efficacy of installing external leak detection in areas of particular environmental sensitivity. DOS in consultation with PHMSA and EPA determined that Keystone should commission an engineering analysis by an independent consultant that would review the proposed Project risk assessment and proposed valve placement. The engineering analysis would, at a minimum, assess the advisability of additional valves and/or the deployment of external leak detection systems in areas of particularly sensitive environmental resources. The scope of the analysis and the selection of the independent consultant would be approved by DOS with concurrence from PHMSA and EPA. After completion and review of the engineering analysis, DOS with concurrence from PHMSA and EPA would determine the need for any additional mitigation measures.
- EPA and other commenters on the draft and supplemental draft EIS recommended consideration of ground-level inspections as an additional method to detect leaks. The PHMSA report (2007) on leak detection presented to Congress noted that there are limitations to visual leak detection, whether the visual inspection is done aerially or at ground-level. A limitation of ground-level visual inspections as a method of leak detection is that pipeline leaks may not come to the surface on the right of way and patrolling at ground level may not provide an adequate view of the surrounding terrain. A leak detection study prepared for the Pipeline Safety Trust noted: "A prudent monitor of a pipeline ROW will look for secondary signs of releases such as vegetation discoloration or oil sheens on nearby land and waterways on and off the ROW" (Accufacts 2007). PHMSA technical staff concurred with this general statement, and noted that aerial inspections can provide a more complete view of the surrounding area that may actually enhance detection capabilities. Also, Keystone responded to a data request from DOS concerning additional ground-level inspections and expressed concerns that frequent ground-level inspection may not be acceptable to landowners because of the potential disruption of normal land use activities (e.g., farming, animal grazing). PHMSA technical staff indicated that such concerns about landowner acceptance of more frequent ground-level inspections were consistent with their experience with managing pipelines in the region. Although widespread use of ground-level inspections may not be warranted, in the start-up year it is not uncommon for pipelines to experience a higher

frequency of spills from valves, fittings, and seals. Such incidences are often related to improper installation, or defects in materials. In light of this fact, DOS in consultation with PHMSA and EPA determined that if the proposed Project were permitted, it would be advisable for the applicant to conduct inspections of all intermediate valves, and unmanned pump stations during the first year of operation to facilitate identification of small leaks or potential failures in fittings and seals. It should be noted however, that the 14 leaks from fittings and seals that have occurred to date on the existing Keystone Oil Pipeline were identified from the SCADA leak detection system and landowner reports. Keystone has agreed to incorporate into its operations and maintenance plan a requirement to conduct inspections of all intermediate valves, and unmanned pump stations during the first year of operation to facilitate identification of small leaks or potential failures in fittings and seals.

- Dust suppression chemicals should not be used within this sensitive region. Many of these chemicals are salts of various formulations. Any advanced dust suppression techniques (beyond the use of watering) should be protective of the high water quality present in this area. Part 2.14 of the Revised Construction, Mitigation, and Reclamation Plan mentions the use of calcium chloride. The use of misting dust suppression systems should be used within sensitive areas to eliminate the need for salt compounds (Nebraska DEQ).
- This project could require authorization under the Nebraska Department of Environmental Quality, National Pollutant Discharge Elimination System, Construction Storm Water General Permit (CSW-GP). Conditions of this permit may require modifications to the stabilization of disturbed ground as discussed within the Revised Construction, Mitigation, and Reclamation Plan. Namely, the CSW-GP requires that inactive ground be stabilized (either permanent or temporary stabilization) if the ground will be inactive for a period of 14 days. This conflicts with the 30 day timeframe present within the U.S. Department of State Keystone XL Project Supplemental Draft EIS (part 4.5.6) (Nebraska DEQ).

3.3.3 Connected Actions

3.3.3.1 Big Bend to Witten 230-kV Transmission Line

The construction and operation of electrical distribution lines and substations associated with the proposed pump stations, and the Big Bend to Witten 230-kV electrical transmission line would have negligible effects on water resources.

3.3.3.2 Bakken Marketlink and Cushing Marketlink Projects

Construction and operation of the Bakken Marketlink Project would include metering systems, three new storage tanks near Baker, Montana, and two new storage tanks within the boundaries of the proposed Cushing tank farm. Keystone reported that the property proposed for the Bakken Marketlink facilities near Pump Station 14 is currently used as pastureland and hayfields and that a survey of the property indicated that there were no waterbodies or wetlands on the property. DOS reviewed aerial photographs of the area and confirmed the current use of the land and that there are no waterbodies associated with the site. A site inspection by the DOS third-party contractor confirmed these findings. As a result, the potential impacts associated with expansion of the pump station site to include the Bakken Marketlink facilities would likely be similar to those described above for the proposed Project pump station and pipeline ROW in that area.

The Cushing Marketlink project would be located within the boundaries of the proposed Cushing tank farm of the Keystone XL Project would include metering systems and two storage tanks. As a result, the impacts of construction and operation of the Cushing Marketlink Project on soils would be the same as potential impacts associated with construction and operation of the proposed Cushing tank farm described in this section. Cushing Marketlink facilities at the Cushing tank farm appear to be located within uplands; although a stream and floodplain appear to be crossed by the pipelines and encroached upon by the metering systems.

Currently there is insufficient information to complete an environmental review of these projects. The permit applications for these projects would be reviewed and acted on by other agencies. Those agencies would conduct more detailed environmental review of the Marketlink projects. Potential water resource impacts would be evaluated during the environmental reviews for these projects and potential water resource impacts would be evaluated and avoided, minimized, or mitigated in accordance with applicable regulations.

3.3.4 References

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