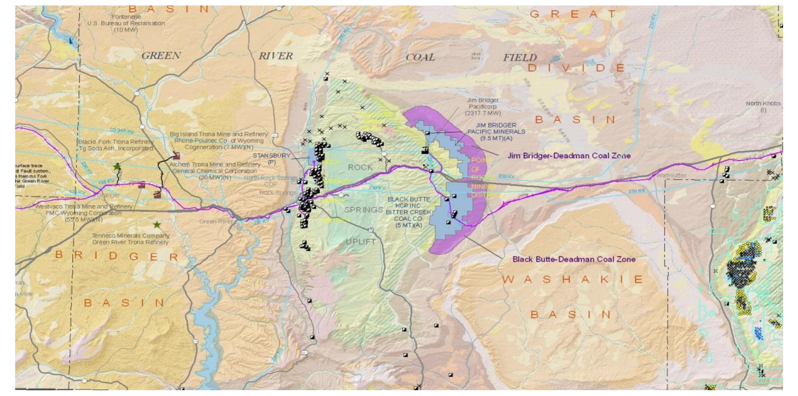
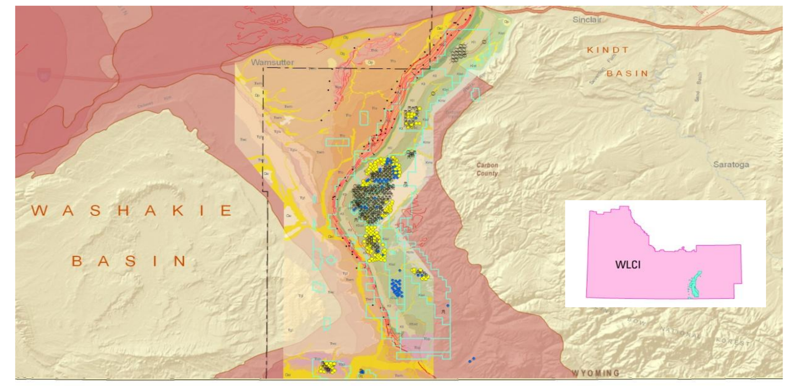
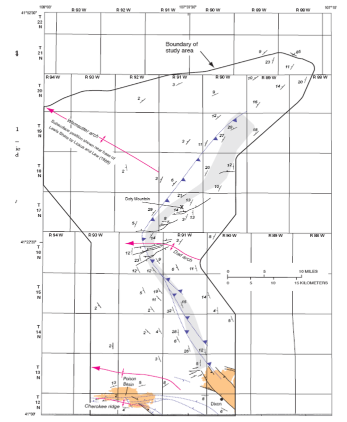
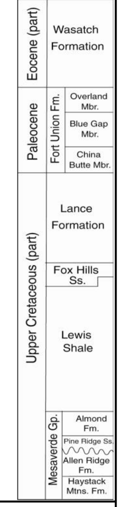
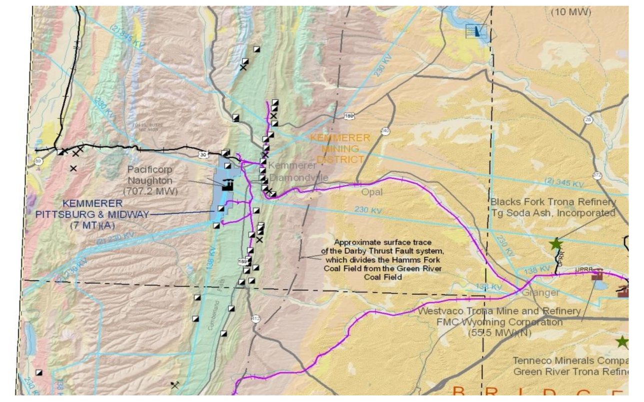
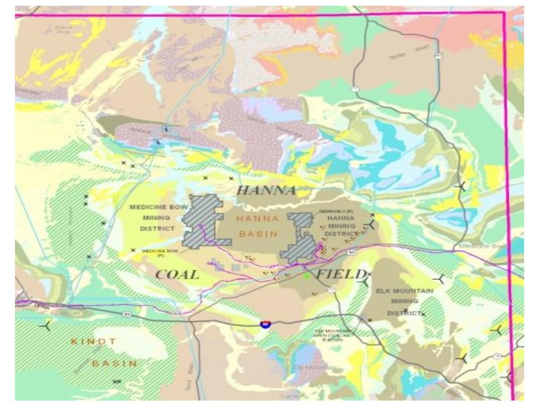
Coal Field		Coal bearing Formations	Mine	Mining History	Age	Coal Beds or Zones	Depositional Environment	Discovery Date	Coal Geochemistry	Infrastructure	Location	Production	Rank	Resources	Structure	Thickness
Green River	 Thumbnail graphic showing the Green River coal field (see plate 1).	Two operators are recovering coal from the Fort Union, Lance and Almond Formations (U.S. BLM, 2008a). Deeper Mesaverde Group coals targeted at the proposed Stansbury Mine.	Presently, mining at the Jim Bridger and Black Butte Mines on the northeastern flank of the Rock Springs Uplift (U.S. BLM, 2008a). Stansbury Mine proposed on the northwest portion of the Rock Springs uplift (see plate 2).	Coal mining in the Rock Springs uplift began as local house and wagon mines along the Overland Trail before 1865 (Evans, 1865). On land granted to the railroad in the Greater Green River Basin at Rock Springs, Black Butte, and Point of Rocks, commercial underground coal mines were opened from 1868 to 1870. The tonnage produced from Union Pacific mines nearly tripled, from 1875 to 1895, spurred on by mechanization. Because of the introduction of diesel locomotives on railroads, the 1940s through 1950s constituted a critical period for the Union Pacific mines in the Rock Springs area (Gardner and Flores, 1989). All but three Union Pacific coal mines were closed by the end of 1954. With the termination of the more than 100-year-long dependency on coal by the railroad, the last Union Pacific mine near Rock Springs closed in 1962. As a response to clean-air regulations, the need for cheaper energy, and the oil embargo, in the 1970s, energy suppliers built coal-fired power plants. Coal in the Rock Springs area once again was on the upswing, particularly in the Jim Bridger and Black Butte Mines as surface mining was introduced. Coal mined since 1974 at the Jim Bridger Mine has almost exclusively supplied the fuel for the nearby 2,100-megawatt Jim Bridger power plant (Flores and Bader, 1999).	Paleocene and Late Cretaceous	As many as five coal beds of the Deadman coal zone of the Fort Union Formation are mined and leased within an area of about 25 mi^2 north and east of Point of Rocks and east and south of Black Buttes (Flores and Bader, 1999). The Deadman coal zone (coal beds D1−D5) is exceptionally well developed along the eastern flank of the Rock Springs uplift where the beds have been referred to as the Jim Bridger deposit (Glass, 1976). The Deadman coal zone is subbituminous in rank and as much as 32 ft thick where the coal beds merge. Only three coal beds (A−C) of the Deadman coal zone may be traced southward into the Black Buttes area (Flores and Bader, 1999).	The Rock Springs area served as a depocenter, from Cretaceous to early Tertiary time, prior to uplift (Keith, 1965; Roehler, 1965; Weimer, 1970; Land, 1972; Levey, 1985). The area was part of a greater foreland basin that extended from western Wyoming to Nebraska. During Cretaceous time, sedimentary infilling of this basin by fluvial, deltaic, and marine deposits was controlled by tectonic movement of the Cordilleran thrust belt and the rise and fall (transgression and regression) of the epeiric sea. During early Tertiary time, Laramide tectonism was characterized by structural partitioning of the Cretaceous foreland basin that influenced the sedimentary infilling by fluvial environments (Perry and Flores, 1994). Cyclic intervals of deposition of conglomeratic sandstone and coal-bearing rocks represent base-level rise and fall controlled by subsidence and tectonism (Flores and Bader, 1999). On fluvial floodplains and in abandoned fluvial channels, organic material that would later become coal, accumulated in peat swamps.	From 1848 to 1850, Howard Stansbury of the Bureau of Topographic Engineers, conducted a survey along the Overland Trail in southern Wyoming (Gardner and Flores, 1989). He labeled the area as a coal basin and reported the presence of coal around Evanston and eastward. He mentioned outcrops of coal along Bitter Creek and near the Point of Rocks, which include Cretaceous and Tertiary deposits (Flores and Bader, 1999). By early 1869, Rock Springs became a significant mining area on the Union Pacific Railroad main line; coal production was mainly from Cretaceous deposits (Flores and Bader, 1999).	The USGS coal quality investigation of the Deadman coal zone indicated the following arithmetic mean values (on an as-received basis) : ash—11.18 percent, total sulfur—0.56 percent, calorific value—9,000 Btu/lb (Stricker and Ellis, 1999). The trace elements that can affect coal utilization and are of environmental concern in the Deadman coal zone, include 0.97 ppm antimony, 21 ppm arsenic, 0.69 ppm beryllium, 0.28 ppm cadmium, 13 ppm chromium, 2.8 ppm cobalt, 5.5 ppm lead, 23 ppm manganese, 0.20 ppm mercury, 9.7 ppm nickel, 2.8 ppm selenium, and 5.1 ppm uranium (n=26; Stricker and others, 1998). Because of the low amounts of sulfur, ash, and trace elements, these coal deposits serve well as an energy resource throughout the next few decades (Flores and Bader, 1999).	For the Jim Bridger mine-mouth electric power plant, the coal resources are expected to continue to contribute fuel supplies (Flores and Bader, 1999).	Sweetwater County (U.S. BLM, 2008a)	One operation is surface, the other is underground, surface and highwall combined.	Subbituminous coal is present in the Fort Union Formation (Flores and Bader, 1999). Black Butte Mine coal specifications: Subbituminous C, 9,400−10,000 Btu/lb., 0.3-0.7 percent sulfur; Union Pacific, 2010a, http://www.uprr.com/customers/energy/coal/wyoming/blkbutte.shtml	For the U.S. Geological Survey 1999 resource assessment of selected Tertiary coals in the Northern Rocky Mountains and Great Plains Region, estimated coal resources of the Deadman coal zone in the Black Butte and Jim Bridger areas were 2.7 billion short tons (Ellis and others, 1999a).	Rock Springs Uplift	Coal deposits in the Deadman coal zone, in the lower 200 ft of the Fort Union Formation are as much as 32 ft thick. The USGS assessment of Fort Union Formation coal beds along the eastern flank of the Rock Springs uplift focused on beds D1, D2, D3, D4, and D5 of the Deadman coal zone (Jim Bridger mine) and the equivalent A, B, and C coal beds (Black Butte mine; Flores and Bader, 1999).
Little Snake River (from Ball, 1909, and Ball and Stebinger, 1910, in Hettinger and others, 2008).	 Thumbnail graphic showing coal stratigraphy in the Rawlins-Little Snake River Area and coalbed natural gas drilling on the Atlantic Rim (see plate 1).	Mesaverde Group and Fort Union Formation (Quillinan and others, 2009; Hettinger and others, 2008).	Exploration and production of coalbed natural gas is across the Atlantic Rim.		Paleocene and Late Cretaceous	Fort Union Formation: coal zones of the China Butte Member and Cherokee coal zone of the Overland Member; Mesaverde Group: primarily the Allen Ridge and Almond Formations (Hettinger and others, 2008)	In the upper member of the Almond Formation, coals developed from peat deposits that accumulated in back-beach barrier islands adjacent to mainland beaches or sediment-filled lagoons. In the lower member, coal developed from peat that accumulated in marshes where splay deposits filled bays and water was shallow enough to allow the growth of vegetation (Hettinger and others, 2008). See also, Green River coal field.	The Atlantic Rim Natural Gas Project (ARPA) began with a 96-coal bed natural gas (CBNG) well proposal submitted by Stone & Wolf in 2000 (U.S. BLM, 2005). The development of natural gas resources in the ARPA involves drilling of approximately 2,000 CBNG wells to recover energy resources. Total new surface disturbance from the drilling program across the ARPA (Federal, State and fee minerals) is limited to a maximum of 7,600 acres, at any given time, and a 6.5-acre/well site short-term (less than 6 years) disturbance goal. The estimated number of gas wells is not a cap or limitation, but an approximation to help establish the surface disturbance limit (U.S. BLM, 2007).	As-received analysis of coal samples near the base of the Allen Ridge Formation shows 6.94 percent ash, 2.25 percent sulfur, and a heating value of 11,218 Btu/lb (Ball and Stebinger, 1910). A coal sample from the upper member of the Allen Ridge shows 8.44 percent ash, 0.49 percent sulfur, and a heating value of 11,009 Btu/lb (Ball, 1909). The average of six analyses of coal in the Almond Formation, show 6.61 percent ash, 0.58 percent sulfur, and a heating value of 10,359 Btu/lb (Ball and Stebinger, 1910). For coal in the China Butte Member of the Fort Union Formation, reported by Dames and Moore (1978a, b, c; 1979a, b, c), ash ranges from 4.8 to 14.63 percent, sulfur content ranges from 0.15 to 1.31 percent, heating values range from 7,319 to 9,786 Btu/lb, and apparent rank varies from subbituminous B to subbituminous C. For coal beds in the Cherokee coal zone, ash yields range from 9.60 to 35.28 percent, sulfur content ranges from 1.03 to 5.74 percent, heating values range from 6,098 to 9,122 Btu/lb, and apparent rank varies from lignite to subbituminous C (Sanders, 1974 and 1975; in Hettinger and others, 2008).		Atlantic Rim (Rawlins-Little Snake River Area, South-Central Wyoming)	Atlantic Rim: 54.9 billion cubic ft of coalbed natural gas was produced as of June, 2010 (WOGCC, 2010).	Subbituminous	The proposed Atlantic Rim Natural Gas project is expected to produce nearly 1,350 billion cubic feet of natural gas, providing enough natural gas to heat 19.3 million homes for one year and generating approximately $958 million in total taxes and royalties (U.S. BLM, 2007).	 Major structural components of the Rawlins–Little Snake River study area (Hettinger and others, 2008).	Hettinger and others (2008) report that, except for the Pine Ridge Sandstone that contains only discontinuous coals, each of the formations in the Mesaverde Group contains at least one coal bed that is more than 1 ft thick. The Haystack Mountains Formation contains one or two coal beds, 1–3 ft thick. In most of the lower nonmarine member, the Allen Ridge Formation contains lenticular coals, generally 1–2 ft thick. They also showed that southeast of the study area, the basal part of the formation contains as many as three coal beds that are 2–4 ft thick. Coals in the upper member are generally 1–7 ft thick and more numerous, but generally grade laterally and vertically to carbonaceous shale over short distances. Coal is present throughout the Almond Formation where coal deposits are 1–16 ft thick, with 4–8 beds at least 5 ft thick. The Fox Hills Sandstone contains a few thin discontinuous coals, including the 8-ft-thick coal at the abandoned Nebraska Mine. The Lance Formation is divided into a lower member and the upper Red Rim Member. Several thin and discontinuous coals about 1–10 ft thick are near the base of the lower member. In the Cherokee coal zone of the Overland Member of the Fort Union Formation, maximum coal thicknesses range from 5 to 41 ft. Maximum coal bed thicknesses of coal zones in the China Butte Member range from 2.5 to 33 ft. Coals 1–30 ft thick are in the main body of the Wasatch Formation near Wamsutter and Creston Junction. 
Hams Fork	 Thumbnail graphic of the Kemmerer Mine in the Hams Fork coal field (see plate 1).	This deposit is composed of multiple coal seams in the Adaville Formation that dip steeply to the west (U.S. BLM, 2008a).	Kemmerer Mine near Kemmerer (U.S. BLM, 2008a)	With the formation of the Kemmerer Coal Company in 1897 by Patrick J. Quealy, the town of Kemmerer was founded. The coal company and the town were named after Quealy's financial backer, Pennsylvania coal magnate Mahlon S. Kemmerer. Although the opening of the Kemmerer mines constituted the major impetus for growth in the area, some mining in the area dates back to the opening of mines by the Union Pacific Coal Co. in 1881 and the construction of the Oregon Short Line Railroad from Granger to Oregon. In 1950, the operation converted to surface mining. The Kemmerer "Big Pit" mine, one of three at the complex, began in 1971 and is the deepest open pit coal mine in the United States (©Union Pacific, 2010b). The mine has an annual output of about 5 million short tons (©Chevron, 2009).	Late Cretaceous	Glass (1977) reported that the Adaville Formation may be equivalent in age to the Mesaverde Group and Lewis and Lance Formations of the Green River region, and is the most important coal-bearing rock in the Hams Fork Region. Ranging from 2,900-4,000 ft in thickness, the Adaville Formation contains more than 32 coals within a 1,000-ft interval, many of which are much thicker than other coals of this age in Wyoming (Glass, 1977). The Adaville No. 1 has a measured thickness of greater than 80 ft.	Lawrence (1992) described the distribution and total coal resources within the Adaville coal field as being controlled by the geographic extent and number of transgressive-regressive pulses. These coals formed during a transgressive sequence with a controlled shoreline via growth faults. In regions where thrust and sediment loads contributed to rapid subsidence rates, the potential for thick coal deposits is greatest. In response to isostatic compensation to thrust and sediment loads of the Sevier orogenic belt during a period of general regression along the western margin of the Cretaceous seaway, stacked marine sand bodies and thick coal deposits accumulated in the Adaville Formation.	The first underground coal mine near Kemmerer, WY, opened in 1881. The Kemmerer mine operation moved above ground in 1950, is located six mi south of town, and is the world's deepest open pit coal mine (©Lasik Computer Services, 2010).	Oder (2003) reported that reductions of ash of 28 percent, pyritic sulfur of 78 percent, arsenic of 31 percent, and mercury of 72 percent on a pounds per million Btu basis were achieved using a two stage ParaMag™ dry magnetic separator. Laboratory scale (200 lb/hr) dry magnetic separation tests of an Adaville series bituminous/subbituminous rank coal from southwestern Wyoming resulted in highly effective separations because of the synergism between the pulverizer and the dry magnetic separator. The clean coal product had a sulfur content of 1.17 $LbSO_2$/MBtu and Btu recoveries of 95 percent for this coal. A practical method of achieving these levels of performance is to retrofit the separators to treat the internal circulation of a pulverizer at the coal-fired power plant (the MagMill™; Oder, 2003). See also *http://www.uprr.com/customers/energy/coal/wyoming/kemmerer.shtml*	See Kemmerer Mine, plate 2.	Lincoln County (US_BLM, 2008a)	Wyoming's deepest open-pit coal mine (U.S. BLM, 2008b)	9,500-10,000 Btu/lb. 0.6−1.0 percent sulfur (©Union Pacific, 2010b)		Darby Thrust Fault system (Jones and others, 2009). Southwestern Wyoming Thrust Belt.	This coal zone possibly best typifies the variable thickness of Wyoming coals, the splitting and coalescing aspect of coal beds, and the diversity of lithologies associated with the coals (Glass, 1977). Several of these subbituminous coals are between 10−30 ft thick; the basal Adaville coal (Adaville No. 1) is locally 82 ft thick. Individual coal beds within the zone cannot be followed for any great distance, due to faulting; however, a zone of Adaville coals can be traced for almost 100 mi north to south.
Hanna	 Thumbnail graphic of the Hanna coal field (see plate 1).	Ferris, Hanna and Medicine Bow Formations	Medicine Bow, Seminoe II, Elk Mountain	Coal was originally mined underground, and was used to fuel steam locomotives on the Union Pacific Railroad. Coal mining practically ceased in the Hanna basin, after the railroads switched from coal-fired to diesel-electric locomotives. Due to increased demand for coal to fuel electric power plants (brought about by passage of the Federal Clean Air Act), coal mining by both underground and surface methods resumed in the 1970s. Because this coal must compete with the easily mined and much cheaper coal from the Powder River Basin, most coal mining activity in the basin has once again nearly ceased (Wyoming State Geological Survey, 2010b).	Paleocene and Late Cretaceous	Ferris and Hanna	These rocks lie in a deep structural trough divided into two separate basins by a large northeast-trending anticline. The Hanna Basin lies to the north; the Carbon Basin lies to the south. Like other intermontane basins in the Rocky Mountain region, this trough formed during the Laramide Orogeny. The Hanna Basin is rather atypical in that most of its sedimentary rocks are tightly folded and faulted, and it is extremely deep for its size with 30,000−35,000 ft of sedimentary rock overlying its crystalline basement (Glass, 1977). During early Ferris time and early Hanna time, major events of downcutting and subsequent infilling of paleovalleys occurred. Braided and meandering streams infilled these paleovalleys (Cavaroc and others, 1992). Base level rises during which alluvial plains were drained mainly by meandering and anastomosed rivers, are reflected by intervening coal-bearing intervals consisting of sandstone, siltstone, mudstone, and coal (Perry and Flores, 1994).	Coal in the Hanna Basin was first discovered by James C. Fremont along the North Platte River near the mouth of Sage Creek (Dobbin and others, 1929). In Fremont's accounts of the "Expedition to Oregon and North California in years 1843-1844", coal deposits elsewhere along the Overland Trail were reported. Coal was found from the North Platte River eastward to Rock Creek (23 mi east of Elk Mountain) by James Evans, who surveyed the proposed Union Pacific rail line in 1865 (Gardner and Flores, 1989). The availability of significant amounts of coal along the Overland Trail, as reported by Fremont and Evans, helped influence the route of the transcontinental railroad.	These coal deposits have low sulfur, ash, and trace-element contents. Stricker and others (1998) reported arithmetic means for contents of arsenic (4.4 ppm), mercury (0.07 ppm), selenium (0.80 ppm), and uranium (1.9 ppm) (n=14, arithmetic mean, on a whole-coal, as-received basis) of the Ferris and Hanna coals in the Hanna and Carbon Basins (Flores and others, 1999a).	There is currently an active mine, a load-out facility and rail spur northeast of Elmo, east of Hanna.	The Hanna and Carbon Basins are in Carbon County, east of the town of Hanna, WY.	Flores and others (1999a) reported that at the time of the 1999 USGS coal assessment, production from the Ferris coals was in open-pit mines, and production from the Hanna coals was in underground and open-pit mines. Arch Coal, Inc., operated surface mines in the Ferris and Hanna coal fields. An underground mine in the Hanna coal field was operated by the Cyprus Coal Company. Seven in-state electric power plants were supported from these coal mines. In 1998, coal production from three mines was more than 3.1 million short tons (Resource Data International, Inc., 1998); as reported in Flores and others, 1999a.	In the Hanna and Carbon Basins, subbituminous and bituminous coal exist in the Paleocene Ferris and Hanna Formations (Dobbin and others, 1929; Berryhill and others, 1950; Glass and Roberts, 1979); as reported in Flores and others, 1999a. Glass and Roberts (1979) reported that the apparent rank of the Ferris and Hanna coals varies from subbituminous A to high volatile C bituminous, ranging from 11,170 Btu/lb for the Ferris coal on the western part of the Hanna Basin to 11,590 Btu/lb for the Hanna coal in the east-central part of the Hanna Basin and 12,270 Btu/lb for the Hanna coal in the Carbon Basin to the east.	Assessment of Ferris and Hanna coal in the Hanna and Carbon Basins (Ellis and others, 1999b) concentrated on the compliant coals of the Ferris 23, 25, 31, 50, and 65, Hanna 77−79, 81, and the Johnson-107 coal beds. Estimates of coal resources in beds thicker than 2.5 ft are : Ferris coals—1.75 billion short tons; Hanna coals—4.26 billion short tons; and Johnson−107 coals—2.7 billion short tons; the total for the two basins—8.71 billion short tons—is a significant regional energy resource (Flores and others, 1999a).	The Hanna and Carbon Basins are structural and sedimentary basins, bounded on the south by the Medicine Bow uplift, on the north by the Sweetwater arch (consisting of the Granite, Shirley, and Seminoe Mountains) and on the west by the Rawlins uplift (Flores and others, 1999a).	In the Hanna and Carbon Basins, 77 coals were identified by Dobbin and others (1929) and Glass and Roberts (1980); of these 47 coals are in the Ferris Formation, and 30 beds are in the Hanna Formation (Flores and others, 1999a). Coal deposits in the Ferris Formation may split and merge within distances as short as 0.1 mi. In the Hanna Formation, coal deposits split and merge over a few mi. Most of the numerous Ferris coals measure less than 6 ft thick, although at least one of the Ferris coals reaches 24 ft thick. Locally, most of the Hanna Formation coals exceed 3 ft in thickness. Glass (1977) stated, "More importantly, the Hanna No. 1, No. 2, and No. 5 coals reach thicknesses of up to 30 ft, 36 ft, and 29 ft thick, respectively."

Coal Fields in Southwestern Wyoming

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