# AUGMENTATION PLAN FOR ROCKY FLATS PLANT

Task 28
of the
Zero-Offsite Water-Discharge Study

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# AUGMENTATION PLAN FOR ROCKY FLATS PLANT

## EXECUTIVE SUMMARY

This report has been prepared for one of several studies being conducted for, and in the development of, a Zero-Offsite Water-Discharge Plan for Rocky Flats Plant (RFP) in response to Item C.7 of the Agreement in Principle (AIP) between the U. S. Department of Energy (DOE) and the Colorado Department of Health (CDH) (DOE and State of Colorado, 1989). The DOE/CDH Agreement Item C.7 states "Source Reduction and Zero Discharge Study: Conduct a study of all available methods to eliminate Rocky Flats discharges to the environment including surface waters and ground water. This review should include a source reduction review."

This report was prepared to provide a preliminary Plan for Augmentation, as required under Colorado Revised Statutes (1973), to provide a mechanism for replacement or substitution of water diverted out of priority as a result of capture of surface-water runoff, storm-water runoff, and tributary ground water under the zero-discharge plan being prepared as part of the Zero-Offsite Water Discharge Study (ASI, 1990a; 1991d).

Because the actual decision related to the zero-discharge plan has not been made, an augmentation plan for RFP cannot be finalized because the actual quantity of augmentation water needed is unknown. The potential range of annual augmentation water quantity at the RFP under various zero-discharge alternatives is estimated to be between 112 ac-ft and 472 ac-ft.

The analyses in this report indicate that the potentially least costly method of supplying augmentation water for zero-discharge alternatives would be to lease water from a senior water right in the Denver metropolitan area. The second least costly method of obtaining augmentation or replacement water appears to be development of non-tributary ground water underlying the RFP site, although this source could only supply between 40 ac-ft and 50 ac-ft annually (ASI, 1991j). The most costly method of obtaining augmentation or replacement water would be to

1991j). The most costly method of obtaining augmentation or replacement water would be to construct an advanced water treatment system on site or at Great Western Reservoir to treat captured surface-water and storm-water runoff to numeric stream standards prior to release.

The source(s) of augmentation water which is finally selected may depend upon the zero-discharge alternative selected. Once a zero-discharge alternative is selected and the quantity and source(s) of augmentation is known, the Augmentation Plan for Rocky Flats Plant would have to be approved by the Colorado Water Court.

# AUGMENTATION PLAN FOR ROCKY FLATS PLANT

## 1.0 INTRODUCTION

### 1.1 BACKGROUND

This report has been prepared for one of several studies being conducted for, and in the development of, a Zero-Offsite Water-Discharge Plan for the Rocky Flats Plant (RFP) in response to Item C.7 of the Agreement in Principle (AIP) between the U. S. Department of Energy (DOE) and the Colorado Department of Health (CDH) (DOE and State of Colorado, 1989). The DOE/CDH Agreement Item C.7 states "Source Reduction and Zero Discharge Study: Conduct a study of all available methods to eliminate Rocky Flats discharges to the environment including surface waters and ground water. This review should include a source reduction review."

### 1.2 SCOPE AND PURPOSE

This report was prepared to provide a preliminary Plan for Augmentation, as required under Colorado Revised Statutes (1973), to provide a mechanism for replacement or substitution of water diverted out of priority as a result of capture of surface-water runoff, storm-water runoff, and tributary ground water under the zero-discharge plan being prepared as part of the Zero-Offsite Water Discharge Study (ASI, 1990a; 1991d). This preliminary Augmentation Plan for the Rocky Flats Plant includes the following: (1) a summary of existing surface-water and ground-water rights in the Walnut Creek, Woman Creek, Big Dry Creek and South Platte River basins; (2) preparation of "straight-line" diagrams showing the location of surface-water rights; (3) review of the Denver Board of Water Commissioners (DWB) agreement with the DOE to provide water to the RFP (DWB and DOW Chemical Company, 1952); (4) estimates of the quantity of non-tributary ground water in storage beneath the RFP; and (5) preliminary estimates

of augmentation water quantities for selected proposed zero-offsite water discharge alternatives from other subordinate study tasks.

The Zero-Offsite Water-Discharge Study has considered the potential for construction of facilities at the RFP which would intercept surface-water runoff, divert and intercept storm-water runoff, and divert or cut off tributary ground-water occurring in the Controlled Area and some active areas of the Buffer Zone. The interception of this tributary surface water and ground water will be considered a diversion and can be curtailed under Colorado water law if the depletions are not replaced so as to prevent injury to vested water rights downstream from the diversion (Holland and Hart, Attorneys at Law, 1990). The Augmentation Plan would provide a feasible way of obtaining replacement water for out-of-priority diversions made as a result of implementation of the zero-discharge plan when capturing potentially contaminated surface and ground waters.

Because the decision related to the actual zero-discharge plan for the RFP has not been made, the water-rights analyses presented herein are generalized. Because this report has been prepared without benefit of legal counsel, the details presented in this study may not be sufficient for water-rights engineering preparation for Colorado Water Court. Where possible, water-rights legal opinions provided by previous studies (ASI, 1990a; DOE, 1991) have been incorporated.

Studies which are subordinate to the Zero-Offsite Water-Discharge Study that would be affected by or affect this preliminary augmentation plan are: Water-Yield and Water-Quality Study of Walnut Creek and Woman Creek Watersheds (Task 4, ASI, 1990c); Rainfall/Runoff Relationships Study (Task 5, ASI, 1991m); Storm Runoff Quantity for Various Design Events Study (Task 6, ASI, 1991b); Design Recurrence Intervals Study (Task 9, ASI, 1990b); Treated Sewage/Process Wastewater Recycle Study (Tasks 11 and 13, ASI, 1991a); Surface-Water and Ground-Water Rights Study (Task 14, ASI, 1991h); Surface-Water Evaporation Study (Task 15, ASI, 1991g); Water-Yield and Water-Quality Study of Other Sources Tributary to Standley Lake and Great Western Reservoir (Task 16, ASI, 1990d); Alternatives to Zero Discharge Study (Task 17, ASI, 1991l); Temporary Water-Storage Capabilities Study (Task 21, ASI, 1991f); Ground-Water

Recharge Study (Task 22, ASI, 1990f); Study of Water Resource Management (Task 23, ASI, 1991k); Bypass Upstream Flows Around Rocky Flats Plant Study (Task 24, ASI, 1991c); Feasibility of Groundwater Cutoff/Diversion Study (Task 26, ASI, 1991i); Non-Tributary Ground-Water Study (Task 29, ASI, 1991j); and Consolidation and Zero-Discharge Plan (Task 30, ASI, 1991e; 1991n). Input from those subordinate tasks which have been initiated or completed were used in this study where appropriate.

# 2.0 POTENTIALLY IMPACTED WATER RIGHTS

## 2.1 SURFACE-WATER RIGHTS

### 2.1.1 Hydrologic Setting

The RFP site is drained by Walnut Creek and Woman Creek, which are part of the Big Dry Creek basin and by Rock Creek, a part of the Coal Creek basin (Figure 1). The RFP site is located in former Water Districts 2 and 6 as defined by the Colorado State Engineer (1979). In 1969, the Colorado Legislature abolished the water districts and established seven water divisions encompassing the seven major river basins in the State (Knudsen and Danielson, 1977). The RFP is located in Water Division 1 (South Platte River basin). Although water districts are no longer legally recognized, this jurisdictional delineation is still being used by the Colorado State Engineer for administrative purposes (Knudsen and Danielson, 1977) and also is used in this report. Big Dry Creek and its tributaries are located in Water District 2 and Rock Creek is located in Water District 6 (Figure 1). The Clear Creek basin, in Water District 7, is south of the RFP and Water Districts 2 and 6. Big Dry Creek is tributary to the South Platte River basin, with the Big Dry Creek confluence with the South Platte River about 1.5 miles (mi) south of Fort Lupton (Figure 1).

There are several ditches, originating in Water District 6, which convey water across the RFP area as shown on Figure 2. These ditches, which are discussed in more detail below, include the Upper Church Ditch, the McKay (Zang) Ditch, and the Kinnear Ditch. The Upper Church Ditch diverts water from Coal Creek in Water District 6 into Water District 2. The Upper Church Ditch enters the RFP site just north of the west access road and proceeds generally northeast (Figure 2). This ditch exits in the northeast corner of the RFP site at about the intersection of Colorado Highway 128 and North Indiana Street. The McKay Ditch, also known as the Zang Ditch, diverts water from Coal Creek in Water District 6 into Water District 2. The McKay Ditch generally runs parallel to the Upper Church Ditch until it enters the McKay Bypass, where

it then runs in a more east-southeasterly direction than the Upper Church Ditch (Figure 2). The McKay bypass was constructed by DOE, to prevent ditch water from flowing down Walnut Creek into RFP's A-series ponds. The McKay Bypass re-enters Walnut Creek downstream from Pond A-4 (Figure 2) and ultimately flows into Great Western Reservoir. The Kinnear Ditch also diverts water from Coal Creek. This ditch flows generally easterly across RFP and discharges into Woman Creek. Kinnear Ditch water ultimately flows into Standley Lake.

Two other ditches convey water across the RFP site. These two ditches are the Smart Ditch and the Mower Ditch. The Smart Ditch diverts water from Rocky Flats Lake, west of RFP, and conveys this water eastward across the south Buffer Zone to Standley Lake. The Smart Ditch exits the RFP site at its southeast corner. The Mower Ditch diverts water from Woman Creek into Mower Reservoir (Figure 2).

Nearby ditches which convey water in the vicinity of the RFP site include the Last Chance Ditch, the South Boulder Diversion Canal, the Church Ditch, the Croke Canal and the Farmers Highline Canal. The Last Chance Ditch diverts water from Coal Creek (Figure 2). Water diverted by the Last Chance Ditch generally flows along the south side of the RFP site and into Standley Lake. The South Boulder Diversion Canal diverts water from South Boulder Creek to Ralston Reservoir (Figure 2). The RFP raw water supply also comes from the South Boulder Diversion Canal, or from Ralston Reservoir if the Canal is not flowing. The Church Ditch diverts water from Clear Creek (Water District 7) to Great Western Reservoir where the water is pumped into the Reservoir. Water also is imported to Water District 2 from Water District 7 (Clear Creek) through the Croke Canal, which discharges into Standley Lake. The Farmers Highline Canal also diverts water from Clear Creek and discharges into Standley Lake.

It is unlikely that the ditches crossing the RFP area will be injured by the zero-discharge plan because provisions have been taken in the various subordinate studies to provide for continued water transport from the west boundary of RFP to the east boundary (ASI, 1991c, 1991h). In addition, none of the actions proposed as part of the zero-discharge plan would change flow

rates in Coal Creek west of the RFP. Similarly, ditches and canals diverting water from Clear Creek to ditches and reservoirs downstream from the RFP are not likely to be injured, because no alternative actions proposed as part of the zero-discharge plan at the RFP would reduce flows in Clear Creek.

### 2.1.2 Surface-Water Rights Locations

The surface-water rights most likely to be impacted by proposed alternative zero-discharge plans at the RFP are those located downstream from the proposed action. These surface-water rights include those in the Big Dry Creek and South Platte River basins. Because the most senior water rights on a stream are supposed to receive water before less senior or junior water rights, only the most senior water rights would receive water during times of shortages. Figure 3 shows a straight-line diagram of the ditches diverting water from Coal Creek into Water District 2 as well as ditches diverting water within Walnut Creek and Woman Creek in the vicinity of the RFP. Figure 4 is a straight-line diagram of the ditches diverting water from Big Dry Creek, and Figure 5 is a straight-line diagram of the ditches diverting water from the South Platte River between the Denver gaging station and the Kersey gaging station which mark the boundaries of Water District 2 on the South Platte River. The relative location of the confluence of Big Dry Creek and the South Platte River also is shown on Figure 5. Water-management activities at the RFP would not impact South Platte River water rights upstream from the confluence of Big Dry Creek within the South Platte River basin.

The most senior water rights on Woman Creek which could be injured by a zero-discharge plan involve the Kinnear Ditch and Standley Lake (Figure 3). For Walnut Creek, the senior water right involves Great Western Reservoir (Figure 3). In Big Dry Creek, the senior water rights involve the Calkins Ditch, the German Ditch, and the Whipple Ditch (Figure 4). According to previous water-rights studies in the vicinity of the RFP reported by DOE (1991) and ASI (1991h), "calls" from downstream senior water rights on the South Platte River probably would keep most of the Big Dry Creek senior water rights out-of-priority during both a dry and an

average runoff year. When a senior water right "calls" for water, junior water rights upstream are to cease diverting water until the senior water right has received its water and the call is removed (ASI, 1991h). Past water administration in Colorado also has recognized the concept of a "futile" call. A futile call can occur when a release of water would not physically reach the senior water right making the call because of channel losses or other losses. Past detailed studies (ASI, 1991h; DOE, 1991) analyzed records of historic senior water priority and the data of South Platte River calls by Water District to determine the historic calling priorities for typical dry year (1963) and a typical average year (1974).

During a dry year, the water rights in the South Platte River basin putting calls on upstream junior water rights generally have been (or would be) more senior than the most senior water rights in Walnut Creek, Woman Creek and Big Dry Creek during the irrigation season (April through September). Therefore, based upon South Platte River calls, the RFP would have to replace on-site runoff stored out of priority during the times the calls were in effect. The percentage of each month during the irrigation season in which South Platte River calls would be in effect for a typical dry year (1963) are summarized in Table 1.

In an average year, such as occurred in 1974, fewer calls from the South Platte River were evident. However, as summarized in Table 1, in July and August of an average year, the majority of Walnut Creek, Woman Creek and Big Dry Creek would be out-of-priority. Therefore, based upon South Platte River calls, the RFP might have to replace on-site runoff stored out-of-priority at the percentages shown in Table 1 for an average year. Because the RFP water rights are junior to all existing downstream water rights, it may have to replace all stored runoff except that occurring during a large storm event in a wet year. For purposes of this augmentation water assessment and plan, it was assumed that runoff from the developed basins at the RFP would be subject to administration by the Colorado State Engineer.

## Table 1

## South Platte River Calls on Water District 2 for a Typical Dry and Average Year

### District 2 Dry Year (1963) Calls

| Month | Range of Priority Calls and Administration Numbers | Number of Days of Calls During Month | Percent of Month Called |
|---|---|---|---|
| April | 05-01-1866 to 11-14-1877<br>5965.00000 to 10180.00000 | 17 | 57 |
| May | 05-01-1866 to 11-05-1874<br>5965.00000 to 9075.00000 | 26 | 84 |
| June | 05-01-1866 to 10-05-1871<br>5965.00000 to 7948.00000 | 25 | 83 |
| July | 10-05-1871 to 10-26-1881<br>7948.00000 to 11622.00000 | 31 | 100 |
| August | 05-03-1866 to 10-26-1881<br>5967.00000 to 11622.00000 | 31 | 100 |
| September | 10-05-1871<br>7948.00000 | 19 | 63 |
| October | 10-05-1871 to 05-31-1907<br>7948.00000 to 21031.00000 | 8 | 26 |

### District 2 Average Year (1974) Calls

| Month | Range of Priority of Calls and Administration Numbers | Number of Days of Calls During Month | Percent of Month Calls |
|---|---|---|---|
| April | No Calls | 0 | 0 |
| May | 10-18-1882 to 05-31-1907<br>11979.00000 to 21031.00000 | 23 | 74 |
| June | 10-18-1882<br>11979.00000 | 7 | 23 |
| July | 10-20-1880 to 10-21-1890<br>11251.00000 to 14904.00000 | 27 | 87 |
| August | 10-18-1882<br>11979.00000 | 31 | 100 |
| September | 10-18-1882 to 10-01-1888<br>11979.00000 to 14154.00000 | 5 | 17 |

Source: Compiled by DOE (1991).

## 2.2 GROUND-WATER RIGHTS

### 2.2.1 Hydrogeologic Setting

The RFP is located 4 mi east of the Front Range section of the Southern Rocky Mountain province and along the western margin of the Colorado Piedmont section of the Great Plains physiographic province (Spencer, 1961). The RFP is located on a pediment alluvium that dips approximately one degree to the east and is dissected by several small streams that flow eastward with their headwaters either on, or one to two mi west of RFP.

The stratigraphic section in the vicinity of the RFP extends from Precambrian to the Quaternary. The strata that crop out at the RFP and directly underlie RFP are, from oldest to youngest, the Pierre Shale, Fox Hills Sandstone, Laramie Formation, and Arapahoe Formation (EG&G Rocky Flats, Inc., 1991). This stratigraphic sequence represents a continuous transition from a fluvial depositional facies through a deltaic environment to a marine depositional facies (EG&G Rocky Flats, Inc., 1991). Table 2 is a summary of the geologic units, thicknesses, and facies that occur in the upper portion of the stratigraphic section present at the RFP. These thicknesses do not necessarily agree with previously published data by VanSlyke and others (1988a, 1988b) on the Arapahoe and Laramie-Fox Hills aquifers. The Fox Hills Sandstone, Laramie Formation, Lower Arapahoe Formation, and Rocky Flats Alluvium have been described in other reports (EG&G Rocky Flats, Inc., 1990; 1991; ASI, 1991h; 1991i; 1991j) and will not be discussed here.

Recent preliminary information from EG&G Rocky Flats, Inc. (J. W. Langman, Jr., personal communication) indicates that the previously described geologic characteristics of the bedrock aquifers at the RFP are being revised. It appears that units underlying the RFP which were previously identified as the Arapahoe Formation actually may be considered part of the Laramie Formation. Because a new geologic characterization has not yet been completed at the RFP, this study uses existing published information and data related to the bedrock aquifers. Additionally,

## Table 2

## Summary of Geologic Units at the RFP

| Unit | Approximate Thickness (ft) | Facies |
|---|---|---|
| Rocky Flats Alluvium | 10 - 100 | Alluvial Fan |
| Lower Arapahoe Formation | 250 | Fluvial (meanders at top, braided at base) |
| Laramie Formation | 690 | Deltaic (distributary and paludal) |
| Fox Hills Sandstone | 75 | Delta - Front |
| Pierre Shale | >8,000 | Marine |

Source: Modified from EG&G, Rocky Flats, Inc. (1991).

the geologic characteristics at the RFP compiled by EG&G Rocky Flats, Inc. (1990; 1991) may vary from extrapolations or interpolations taken from U.S. Geological Survey (USGS) publications. Generally, the EG&G data are more reliable because they represent on-site investigations; whereas, the USGS data are from wells outside the RFP boundary.

The Colorado State Engineer has determined that the ground water in bedrock aquifers (Fox Hills Sandstone, Laramie Formation, and Lower Arapahoe Formation) underlying the RFP is non-tributary (VanSlyke and others, 1988a; 1988b). The Colorado State Engineer will permit overlying landowners, or those with control of the land surface overlying non-tributary ground water, to beneficially use that non-tributary ground water at an average rate which would deplete the resource in 100 years, or a withdrawal rate of one percent of the non-tributary ground water per year. According to interpretation of the Colorado State Engineer's maps of the Laramie-Fox Hills Aquifer at the RFP (VanSlyke and others, 1988b), all the Laramie-Fox Hills aquifer underlying the RFP is considered by the Colorado State Engineer to be non-tributary. Water withdrawal in excess of one percent per year is allowed pursuant to a "banking provision" as long as the total volume of water withdrawn does not exceed the product of the number of years since the date of issuance of the appropriate well permit or the date of determination of the right to this ground water by the Water Court, whichever comes first, and the allowed average annual amount of withdrawal (Holland & Hart, Attorney of Law, 1990).

The amount of non-tributary ground water legally recoverable from the Laramie-Fox Hills aquifer underlying the RFP can be calculated, based upon the average saturated thickness of the aquifer (estimated to be about 120 feet (ft)), the specific yield (presumed by the Colorado State Engineer to be 15 percent), and the surface acreage overlying the non-tributary RFP area (measured from maps to be about 6,350 acres (ac)). Therefore, the estimated non-tributary water legally recoverable from the Laramie-Fox Hills aquifer underlying the RFP is about 114,300 acre-feet (ac-ft)(ASI, 1991j). Annual non-tributary withdrawals may be made over a 100-year period at a rate of about 1,140 acre-feet per year (ac-ft/yr) (about 700 gallons per minute (gpm)). This

non-tributary ground water could be pumped to satisfy replacement or augmentation water for the zero-discharge plan.

According to the Colorado State Engineer (VanSlyke and others, 1988a), the water in the lower Arapahoe Formation underlying the RFP also is non-tributary. The amount of "legally" recoverable non-tributary Arapahoe Formation water underlying the RFP can be estimated based upon the average saturated thickness of the aquifer (estimated to be about 15 ft), the specific yield (presumed by the Colorado State Engineer to be 17 percent), and the surface acreage overlying the non-tributary RFP area (measured from maps to be about 4,970 ac). Therefore, the estimated legally recoverable non-tributary water in the Arapahoe Formation aquifer underlying the RFP is about 12,700 ac-ft (ASI, 1991j). Annual non-tributary withdrawals of this water may be made over a 100-year period at a rate of about 127 ac-ft/yr (about 80 gpm). This non-tributary ground water could be used to satisfy replacement or augmentation water for the zero-discharge plan.

The saturated thickness of alluvial and valley fill materials was estimated at the RFP by subtracting the elevation of the top of bedrock from the elevation of the water table in all of the alluvial and valley-fill wells. The resulting 10-ft difference (saturated thickness) was used to estimate the quantity of water in storage in the alluvial and valley fill materials underlying the RFP (EG&G Rocky Flats, Inc., 1991). The total average thickness of the alluvial and valley fill materials at the RFP has not been estimated. An assumed porosity of 30 percent for the alluvium and valley fill, and an areal extent of 6,470 ac, give a volume of water in storage in the alluvium and valley fill at the RFP of about 19,400 ac-ft. However, all of the water in storage in the alluvium and valley fill materials at the RFP is considered by the Colorado State Engineer to be tributary to streams in the area. Therefore, any diversion of water from this aquifer could constitute an out-of-priority diversion subject to the same administration as diversion of water from a stream.

### 2.2.2 Ground-Water Rights Locations

Based upon well permit tabulations of the Colorado State Engineer, there are over 230 registered wells within 2 miles of the RFP boundary. The locations of these registered wells were shown on Plate I and summarized in Appendix A, Table A-1 of the Task 14 report (ASI, 1991h). Based upon the locations of wells registered with the Colorado State Engineer within 2 miles of RFP, as many as 20 wells are judged to be completed in the Laramie-Fox Hills Aquifer downgradient (assumed to be generally north and east) from RFP (ASI, 1991h). It is estimated that as many as 70 wells are completed in the lower Arapahoe Formation (or Laramie Formation, depending upon the geologic interpretation at the RFP) downgradient (assumed to be north and east) from RFP (ASI, 1991h). ASI (1991h) also estimated that about 10 wells are completed in the alluvial and valley fill aquifers downgradient (assumed to be generally north and east) from the RFP. The remaining 130 wells identified by well permits are either upgradient (assumed to be generally south and west) of RFP or could not be field verified (ASI, 1991h).

The wells completed in the Arapahoe and Laramie-Fox Hills aquifers may not be legally impacted by pumping of non-tributary water from these aquifers at the RFP. Interpretation of the Colorado State Engineer's administration of non-tributary ground water in the Denver basin indicates that, if potentiometric surfaces drop due to non-tributary ground-water pumping, all those using the aquifer share in the piezometric surface drop. Therefore, it is not anticipated that water pumped by RFP wells from non-tributary ground water sources would cause depletions or injury to downgradient wells or to downstream surface-water rights.

The downgradient alluvial wells could be impacted adversely if water is diverted out of priority as a result of zero-discharge activities. Water for these wells would have to be replaced or augmented under Colorado Statutes.

## 2.3 PRELIMINARY AUGMENTATION WATER QUANTITY

This section quantifies, in a preliminary manner, the amounts of surface water and ground water at the RFP which would have to be augmented under various zero-discharge plan scenarios. The bases for the estimates of surface water and ground water quantities which would have to be augmented are the relevant subordinate study-task reports.

### 2.3.1 RFP Water Supply

The RFP purchases raw water for both domestic and industrial use from the Denver Board of Water Commissioners (DWB) (Holland & Hart, Attorneys at Law, 1990). Raw water for use at the RFP facilities is either diverted directly from the South Boulder Diversion Canal or is pumped approximately 5.7 mi from Ralston Reservoir (Figure 2). Both of these water sources rely upon trans-mountain diversion water. Water from the South Boulder Diversion Canal is the primary RFP raw water source, due to both proximity and gravity flow. Water is pumped from Ralston Reservoir only when the South Boulder Diversion Canal is not flowing, usually during the winter.

The contract for sale of water to RFP was entered into between the City and County of Denver, acting through its Board of Water Commissioners, and the Dow Chemical Company, the then-operator of RFP, on October 28, 1952 (DWB and DOW Chemical Company, 1952). Interpretation of the contract by Holland & Hart, Attorneys at Law (1990) indicated that the DWB would furnish water to the RFP at a rate of 1.5 million gallons per day (mgd), and that the contract would be renewed automatically from year to year unless notice to the contrary was given by either contract party. The future water supply available to the RFP from the DWB is subject to future needs and requirements for water of the City and County of Denver. The contract is assignable to any successor to Dow as operator of the RFP. Further interpretation of the contract by Holland & Hart indicated that the contractual provisions did not indicate that the raw water supplied by the DWB could not be used and reused to extinction by the operator of

the RFP. Although water diverted by the DWB and supplied to its various customers is subject to system-wide return-flow obligations, Holland & Hart's analysis indicated no authority which would require an individual recipient of DWB water to return a specified percentage of that water to the stream after its initial use. It should be noted that if the DWB were to notify the RFP that the contract in future years would be changed to reflect a return-flow provision, then zero-discharge options may require replacement of water which would normally have been returned after its initial use.

A legal opinion was obtained from Holme, Roberts and Owen, Attorneys at Law (1990), regarding return flows from DWB water sold to RFP (DOE, 1991). Because the source of the purchased water is trans-basin and trans-mountain, Holme, Roberts and Owen indicated that the appropriator of such water (that is, the DWB) has the right to use and reuse such water to extinction. However, because the RFP contract is on a year-to-year term, the concurrence of the DWB related to 100 percent consumption use of the supply would be advisable. The DWB may require that some of the water used at RFP be returned, and that these return flows be to the South Platte River basin.

In October 1978, Rockwell International, then-operator of RFP, asked the DWB for a letter clarifying the status of reuse of water supplied by the DWB (Rockwell International, 1978). In November 1978, the DWB responded to Rockwell International (DWB, 1978) that, pending negotiation of a new contract between Rockwell/DOE and the DWB, reuse of water was prohibited. However, in July 1979, the DWB allowed DOE to place the reverse-osmosis (RO) water treatment plant at RFP into operation and to reuse water from the RO plant (DOE, 1979). The RO plant at the RFP had the capability to treat 648,000 gallons per day (gpd) if operated continuously. This capacity could reuse all of the estimated RFP sanitary effluent of 237 ac-ft/yr. Therefore, it is judged that the DWB was aware that total reuse of purchased water at RFP was possible and that the DWB agreed to this total reuse.

Both Holland & Hart, Attorneys at Law (1990) and Holme, Roberts and Owen, Attorneys at Law (1990) recognized that under Colorado water law, absent bad faith, the point of discharge of wastewater or effluent may be changed by the discharger, even if that change adversely affects other water users. Therefore, they concluded that the RFP could reuse its sanitary treatment plant (STP) effluent involving DWB-purchased water without having to replace the source of water, even though it might adversely affect a downstream water right.

Historical water purchases from the DWB by the RFP have been compiled by others based upon RFP data (ASI, 1988; 1990e; 1991a; 1991f). Annual water purchases for the 11-year period 1971, 1972, 1980 through 1987, and 1989 averaged about 395 ac-ft/yr, and ranged from 283 ac-ft/yr in 1981 to 596 ac-ft/yr in 1971. Typically, the RFP discharges between 227 ac-ft/yr and 237 ac-ft/yr of effluent from the STP (ASI, 1991h). Thus, the RFP, under average conditions, may have to replace this water, about 237 ac-ft annually, if the DWB changed terms of the water-purchase contract to explicitly prohibit purchased water reuse to extinction.

### 2.3.2 Surface-Water Runoff

An important water-rights issue involves the amount of depletion the RFP contributes to the existing stream system. Depletion is calculated as the water used minus the return flow, corrected for any lag time. Depletion to the stream, not water use, determines how much augmentation water or replacement water would have to be provided. Results of Task 17 (ASI, 1991l) and Task 21 (ASI, 1991f) included a description of preferred alternatives for control of STP effluent, surface-water runoff, storm-water runoff, and ground water at RFP. The estimated replacement or augmentation water quantity for various preferred alternatives was presented in Task 14 (ASI, 1991h).

Surface-water runoff from that part of the RFP where future runoff may be controlled (areas varying from 1.9 square miles ($mi^2$) to 5.5 $mi^2$) has been estimated to be between about 125 ac-ft/yr and 280 ac-ft/yr (ASI, 1991f). Results of the Task 14 study report (ASI, 1991h) indicated

that the annual quantity of replacement or augmentation water for surface-water runoff may range from about 100 ac-ft to 223 ac-ft, based upon South Platte River calls and assumed conditions of a dry year such as that which occurred in 1963. Based upon the percentage of the monthly runoff which would have to be augmented (Table 1), that quantity of replacement or augmentation water would have to be made available to downstream water rights during the irrigation season (that is, the months of April through September). Additional augmentation water during the non-irrigation season (October through March) also may occur occasionally, but these quantities of water would not be based upon South Platte River calls but rather upon downstream senior water rights in the Big Dry Creek basin. It is unlikely that non-irrigation season augmentation water for downstream water rights would be significant, based upon the South Platte River calls shown in Table 1. The estimated quantities of replacement or augmentation water are based upon reservoir operational studies presented in Task 21 (ASI, 1991f) and Task 17 (ASI, 1991l) and include surface-water runoff that would have to be released based upon South Platte River calls. The reservoir operational studies assumed that the dry year South Platte River calls occurred in every year of the 50-year operational study. The estimated surface-water runoff was calculated using monthly synthetic flows generated as described in Task 21 (ASI, 1991f).

### 2.3.3 Ground Water

In Task 26 (ASI, 1991i), the quantity of alluvial ground water which would be diverted or pumped for control of contaminant plumes at the RFP was estimated. The preferred alternative for control of ground water at the RFP, based upon Task 26, involved the use of individual well clusters downgradient from known contaminant plumes. The resulting annual alluvial ground water which would be pumped and treated at the RFP for the preferred scenario was about 12 ac-ft/yr (ASI, 1991i), which is quite small relative to other water volumes which would have to be augmented.

### 2.3.4 Summary

The total quantity of augmentation water which would have to be replaced at the RFP for downstream water rights because of out-of-priority diversions as part of a zero-discharge plan can be estimated from the component values presented above. Annually, about 237 ac-ft of STP effluent may have to be replaced to the South Platte River basin to satisfy the DWB if it decided that part of the trans-mountain and trans-basin water supplied to the RFP should be returned to the stream system. Between 100 ac-ft and 223 ac-ft annually of surface-water runoff may have to be replaced to the South Platte River basin, assuming a dry year and South Platte River calls. The actual amount of augmentation water would depend upon the selected zero-discharge alternative at the RFP. The average annual quantity of tributary ground water which may have to be replaced or augmented would be on the order of 12 ac-ft, based upon the preferred alternative for controlling contaminant-plume movement at the RFP. Thus, the total estimated average annual quantity of replacement or augmentation water for various zero-discharge alternatives may range from about 112 to 472 ac-ft. This range includes the average annual STP effluent from the RFP, the average annual surface-water runoff, and the average annual ground-water quantity for contaminant-plume control.

DOE (1991) has estimated that the annual augmentation water for alternatives to zero discharge at the RFP might require between 220 ac-ft and 500 ac-ft of water during a dry year. During an average year, this augmentation water requirement may increase to between 260 ac-ft and 540 ac-ft. It should be noted that these DOE estimates generally assume worst-case scenarios for STP effluent, surface-water runoff, and storm-water runoff water replacement or augmentation.

# 3.0 POTENTIAL SOURCES OF AUGMENTATION WATER

Potential sources of augmentation (or replacement) water for release downstream to offset depletions due to implementation of a zero-discharge plan may include surface water, ground-water or a combination of these. Surface-water sources might include the purchase or lease of water from another senior water right. Ground-water sources may include pumping of non-tributary ground water for release downstream. This non-tributary ground water may come from the bedrock aquifers beneath the RFP. The potential for each of these sources to meet the preliminary estimated annual augmentation water demand of between 112 ac-ft and 472 ac-ft is discussed below.

## 3.1 SURFACE WATER

Surface-water sources which could be used as augmentation (replacement) water for downstream senior water rights would vary, depending upon the zero-discharge alternative implemented. These sources may include leasing surface water from rights in the Clear Creek basin or South Platte River basin from an existing senior water-right holder, such as Coors (Neil Jaquet, personal communication). Such a lease agreement should include the quantity, timing and quality of the water which would be released over a specified duration. Some of the uncertainties with lease water is that it is generally not guaranteed to be available when needed. In the case of Coors, lease water for augmentation or replacement would be for a 5-year maximum period with no guarantee of renewal (Neil Jaquet, personal communication). The annual cost of leased water in the Denver metropolitan area is typically about $300 per ac-ft.

If DOE purchases Great Western Reservoir as indicated in the Rocky Flats Surface Water Management Plan (DOE,1991) the water rights for this reservoir also should be purchased. These water rights include storage of 1,595.74 ac-ft annually with a storage capacity of 3,250 ac-ft. The City of Broomfield also owns more than 2000 inches of Church Ditch water having an average annual yield of between 2,000 ac-ft (City of Broomfield records) and 3,000 ac-ft

(Colorado State Engineer's records) (ASI, 1990d; 1991h). It is highly recommended that this Church Ditch water right should be included in the Great Western Reservoir purchase. The Great Western Reservoir and Church Ditch water rights could be used as augmentation or replacement water if water-quality considerations are addressed. If DOE purchases Great Western Reservoir, the Colorado Department of Health may require that the quality of water in the reservoir should meet or exceed the rather stringent numeric stream standards currently in effect on Walnut Creek prior to release downstream. The unit cost of such an augmentation system have been estimated to be on the order of $30,000/ac-ft (ASI, 1991f) assuming that Great Western Reservoir is rehabilitated to meet Colorado dam-safety requirements. The unit cost of this augmentation-water option includes the construction and operation of an advanced water treatment plant to treat surface-water and storm-water runoff to numeric stream standards prior to release downstream.

Another source of augmentation water could be the long-term storage and release, as necessary, of treated surface-water runoff which has been captured on site. If an advanced water treatment plant, proposed by several of the zero-discharge alternatives (ASI, 1991f; 1991n; DOE, 1991), is constructed at the RFP, then treated water of a quality meeting numeric stream standards could be used as augmentation or replacement water for downstream senior water rights. In this manner, the RFP could become self-augmenting for surface water and ground water diverted out of priority. If a new off-channel on-site storage reservoir were constructed, the estimated cost of providing augmentation water would decrease from $30,000/ac-ft to about $12,000/ac-ft (ASI, 1991f).

## 3.2 GROUND WATER

Non-tributary ground water underlying RFP could be used to provide partial replacement or augmentation water to downstream water rights. The estimated legally recoverable quantity of non-tributary ground water in the Arapahoe and Laramie-Fox Hills aquifers underlying the RFP is about 127,000 ac-ft under current applicable resource-management guidelines (ASI, 1991h; 1991j; EG&G Rocky Flats, Inc., 1991). The Colorado State Engineer would permit this water

to be extracted at a rate of about 780 gpm over a 100-year period. However, not all of this water could be easily or economically extracted.

In Task 29 (ASI, 1991j), the feasibility of withdrawing water from the non-tributary Arapahoe and Laramie-Fox Hills aquifers underlying the RFP was assessed, along with an analysis of a hypothetical wellfield at the RFP. Because the saturated thickness of the Arapahoe Formation underlying RFP is relatively small (less than 35 ft), it was concluded that recovery of water from this aquifer for augmentation or replacement water was not feasible. Some non-tributary water is recoverable from the Laramie-Fox Hills aquifer, however. Based upon the hydraulic characteristics of the Laramie-Fox Hills aquifer, drawdowns were calculated for various withdrawal rates assuming that the aquifer was infinite in areal extent and that it had an initial potentiometric surface 700 ft above the top of the aquifer (confined). Drawdowns in excess of 700 ft would indicate that withdrawal of water at the indicated pumping rate or well spacing was not feasible.

Results of the drawdown analysis indicated that a maximum of between 40 ac-ft and 50 ac-ft annually could be withdrawn from non-tributary Laramie-Fox Hills ground water underlying the RFP (ASI, 1991j). This quantity is not enough to offset the estimated 112 ac-ft to 472 ac-ft of augmentation or replacement water needed under various zero-discharge alternatives, however, it could satisfy that need in part. Therefore, a supplemental source of augmentation or replacement water is needed in addition to non-tributary ground water underlying the RFP. Pumping 50 ac-ft/yr of Laramie-Fox Hills non-tributary ground water from beneath the RFP and transporting it 1 mi to a point of use was estimated by ASI (1991j) to cost about $2,600/ac-ft annually. This cost is substantially larger than a typical supplemental surface-water lease agreement which might cost about $300/ac-ft.

## 4.0 AUGMENTATION PLAN FOR ROCKY FLATS PLANT

Because the decision related to the actual zero-discharge plan has not been made, an augmentation plan for the RFP cannot be finalized because the actual quantity of augmentation water needed is unknown. The potential range of annual augmentation water quantity at the RFP under various zero-discharge alternatives is estimated to be between 112 ac-ft and 472 ac-ft. The above analyses indicate that the potentially least costly method of supplying augmentation water for zero-discharge alternatives would be to lease water from a senior water right in the Denver metropolitan area. The second least costly method of obtaining augmentation or replacement water appears to be development of non-tributary ground water underlying the RFP, although this source could only supply between 40 ac-ft and 50 ac-ft annually. The most costly method of obtaining augmentation or replacement water would be to construct an advanced water treatment system on site or at Great Western Reservoir to treat captured surface-water and storm-water runoff to numeric stream standards prior to release.

The source(s) of augmentation water which finally is (are) selected may depend upon the zero-discharge alternative selected. Once a zero-discharge alternative is selected and the quantity and source(s) of augmentation is known, the Augmentation Plan for Rocky Flats Plant will have to be approved by the Colorado Water Court.

## 5.0 ACKNOWLEDGMENTS

This study was conducted under the general supervision of Mr. Michael G. Waltermire, P.E., Project Manager, Advanced Sciences, Inc. (ASI). Work involving this project task was under the technical direction of Dr. James R. Kunkel, P.E., ASI Principal Scientist. This study report was written by Dr. Kunkel, with assistance from Mr. Nick Massaro, ASI Draftsmen. This report was reviewed by Dr. Timothy D. Steele, P.H., ASI Physical Sciences Group Manager. The EG&G responsive reviewer of this report was R. A. Applehans, PE/EWE. This report was prepared and submitted in partial fulfillment of the Zero-Offsite Water-Discharge Study being conducted by ASI on behalf of EG&G Rocky Flats, Inc. EG&G's Project Engineer for the Study was Mr. R. A. Applehans of EG&G's Plant Engineering/Environmental and Waste Engineering (PE/EWE) division.

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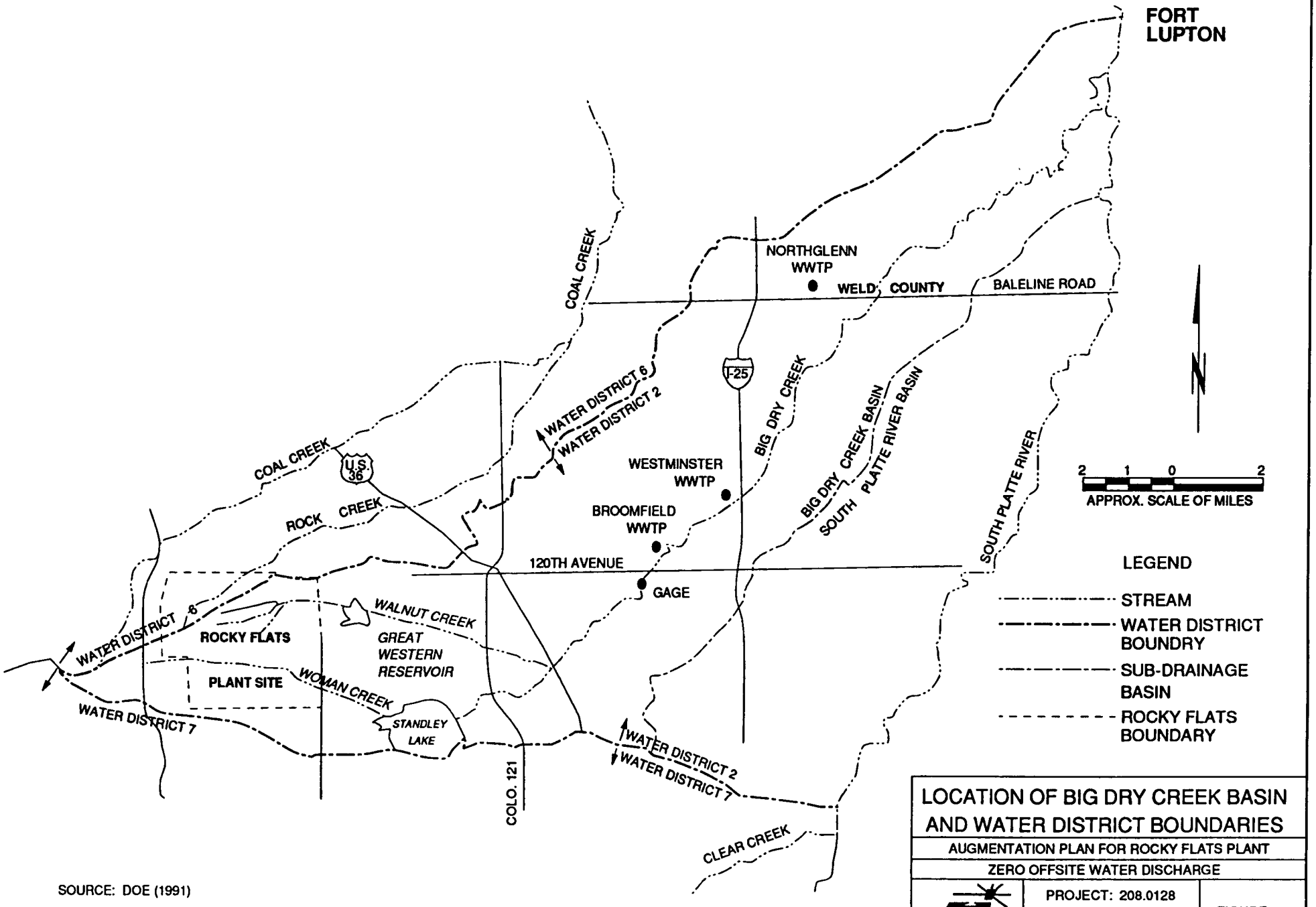



SOURCE: DOE (1991)

# LOCATION OF BIG DRY CREEK BASIN AND WATER DISTRICT BOUNDARIES

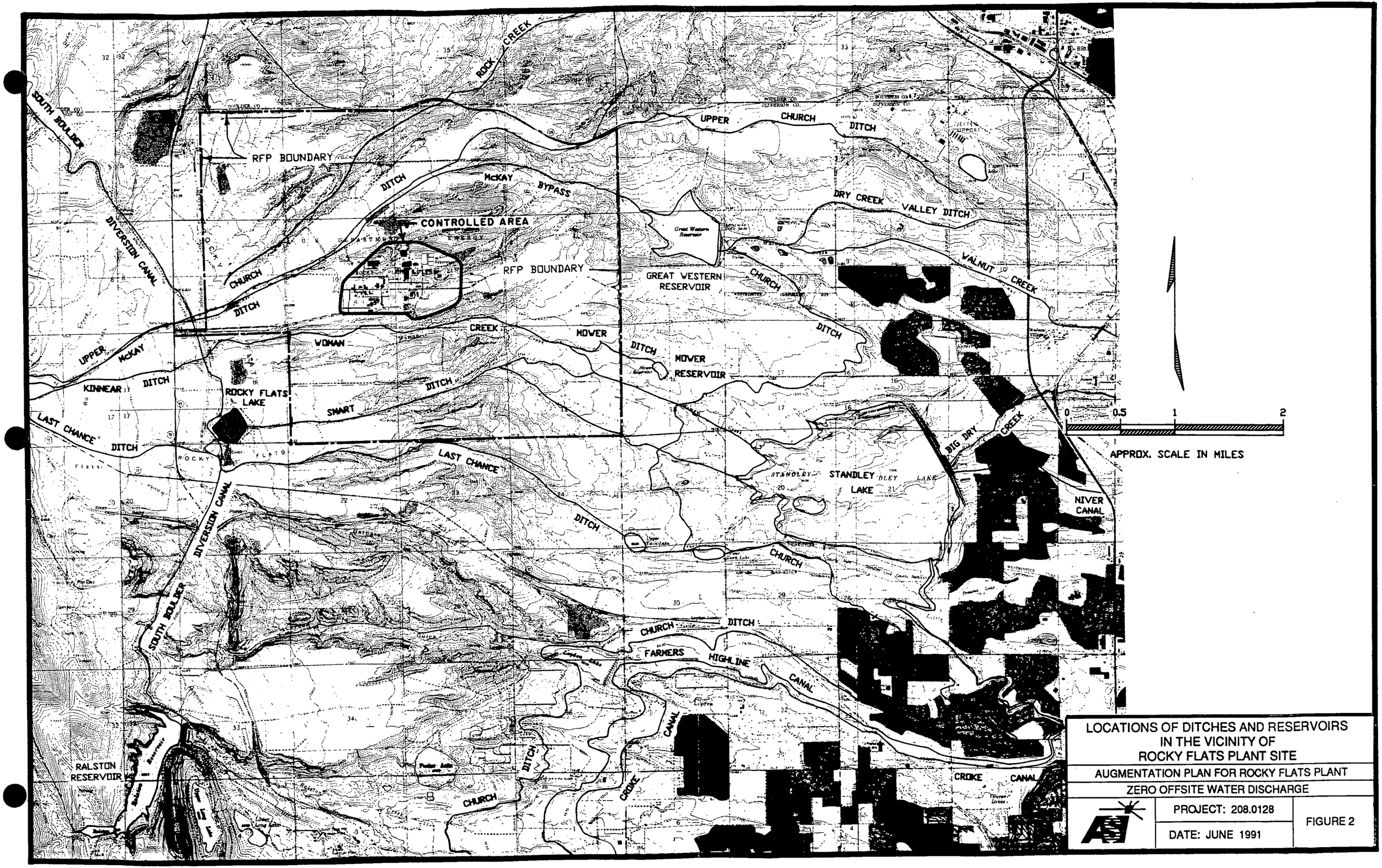
AUGMENTATION PLAN FOR ROCKY FLATS PLANT

ZERO OFFSITE WATER DISCHARGE

PROJECT: 208.0128

DATE: JUNE 1991

FIGURE 1



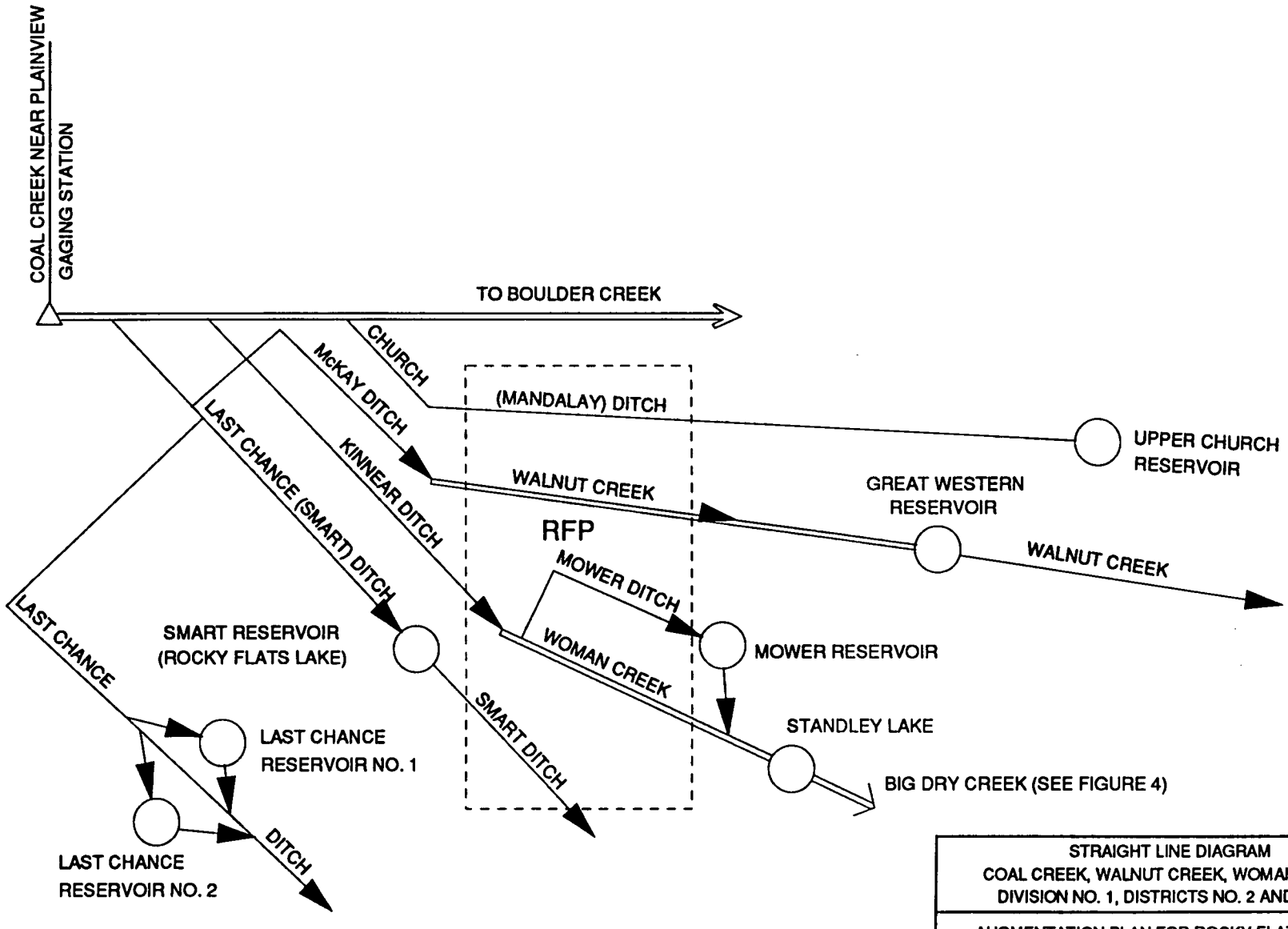

LOCATIONS OF DITCHES AND RESERVOIRS
IN THE VICINITY OF
ROCKY FLATS PLANT SITE

AUGMENTATION PLAN FOR ROCKY FLATS PLANT
ZERO OFFSITE WATER DISCHARGE

PROJECT: 208.0128

DATE: JUNE 1991

FIGURE 2




SOURCE: DOE, 1991

STRAIGHT LINE DIAGRAM
COAL CREEK, WALNUT CREEK, WOMAN CREEK
DIVISION NO. 1, DISTRICTS NO. 2 AND NO. 6

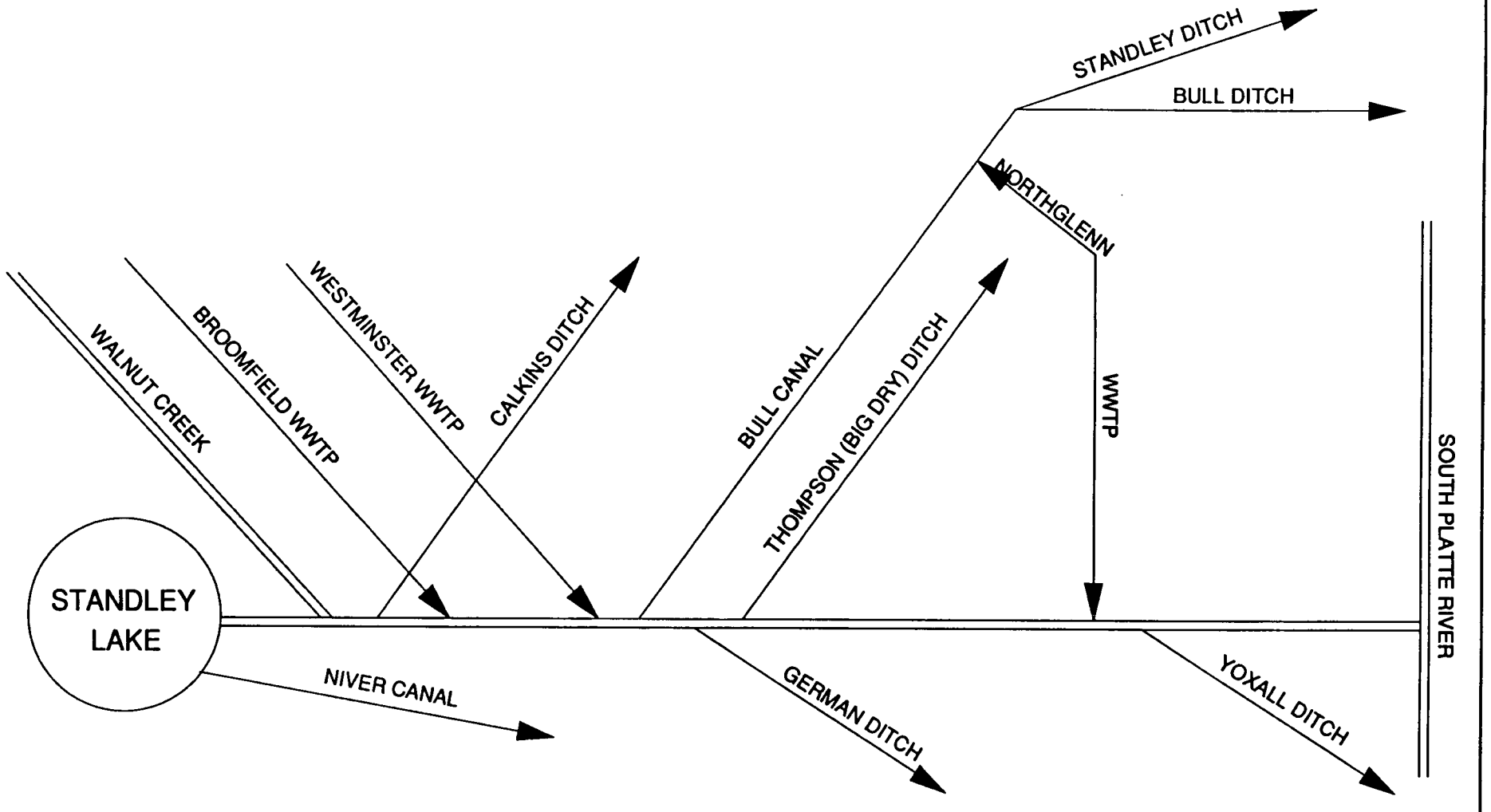
AUGMENTATION PLAN FOR ROCKY FLATS PLANT

ZERO OFFSITE WATER DISCHARGE

PROJECT: 208.0128

DATE: JUNE 1991

FIGURE 3




SOURCE: DOE, 1991

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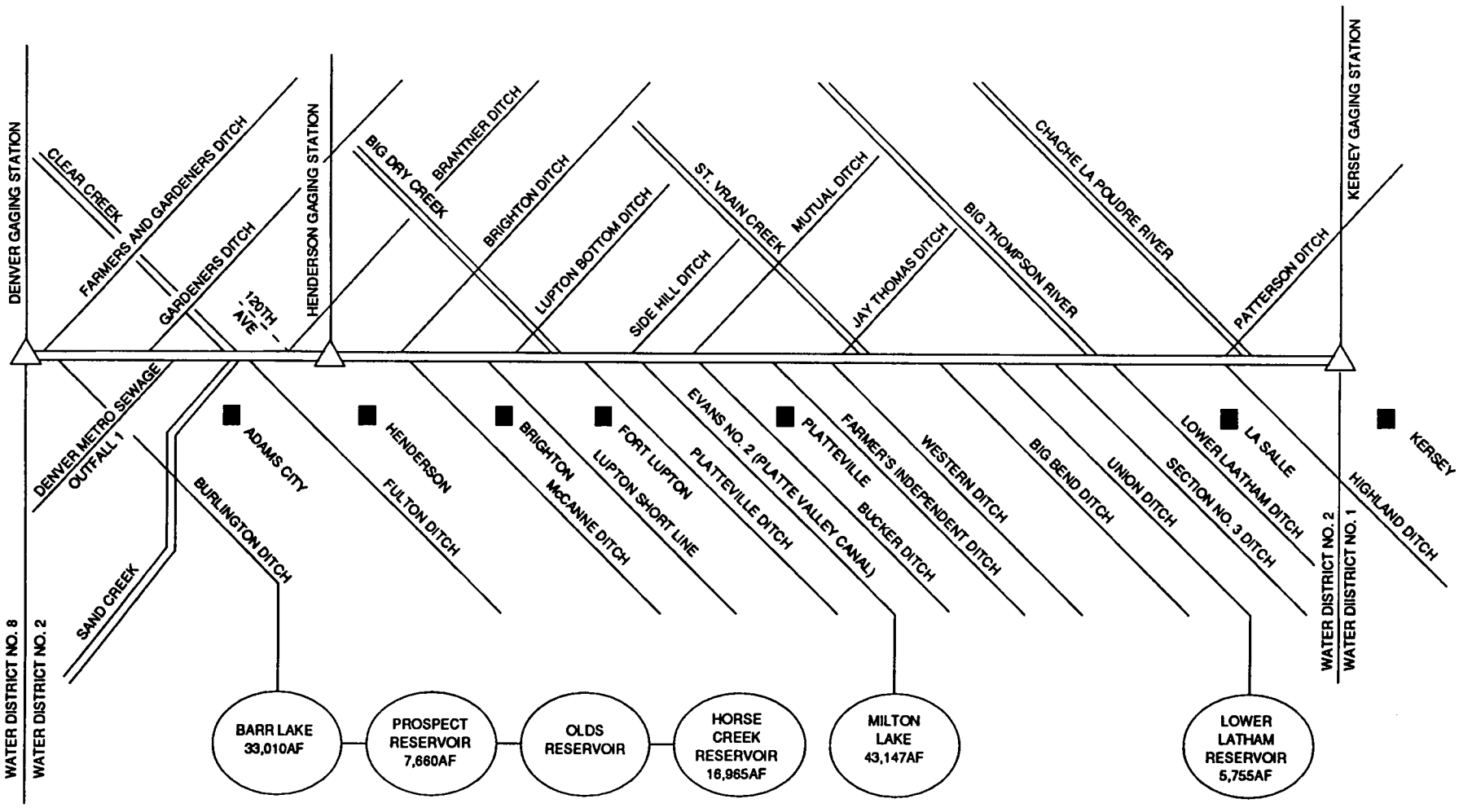
|---|---|
| STRAIGHT LINE DIAGRAM<br>BIG DRY CREEK<br>DIVISION NO. 1, DISTRICT NO. 2 | |
| AUGMENTATION PLAN FOR ROCKY FLATS PLANT | |
| ZERO OFFSITE WATER DISCHARGE | |
| PROJECT: 208.0128<br>DATE: JUNE 1991 | FIGURE 4 |




SOURCE: DOE, 1991

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| STRAIGHT LINE DIAGRAM<br>SOUTH PLATTE RIVER<br>DIVISION NO. 1, DISTRICT NO. 2 |
| AUGMENTATION PLAN FOR ROCKY FLATS PLANT |
| ZERO OFFSITE WATER DISCHARGE |

| | | |
|---|---|---|
| | PROJECT: 208.0128 | FIGURE 5 |
| | DATE: JUNE 1991 | |