

# WYPDES Permitting Guideline for CBM Discharges to Irrigated Drainages of the Powder River Basin

## Scope:

The permitting requirements below apply to drainages with existing irrigation uses, located within the structural Powder River Basin of Wyoming, including the hydrologic basins of the Tongue, Powder and Little Powder Rivers. Existing irrigation uses are defined by WDEQ as follows:

**Artificially Irrigated Lands:** Artificially irrigated lands are those where water is intentionally applied for agricultural purposes. Artificially irrigated lands will be identified by the presence of canals, ditches, spreader dikes, spray irrigation systems or any other constructed mechanism intended to divert water from a stream channel for application on adjacent lands.

**Naturally Irrigated Lands:** Naturally irrigated lands are areas of land along stream channels that have enhanced vegetative production due to periodic natural flooding or sub-irrigation. Naturally irrigated lands are those lands where a stream channel is underlain by unconsolidated material and on which the combination of stream flow and channel geometry provides for enhanced productivity of agriculturally significant plants. Naturally irrigated lands may be identified by an evaluation of infra-red aerial photography, surficial geologic maps, wetland mapping, landowner testimony or any combination of that information. For permitting purposes, naturally irrigated lands are subject to water quality protection when they total 20 acres or more within a drainage, and are generally at least 50 feet wide.

## General Requirements For Irrigation Protection:

### Planning:

Prior to issuing new or renewed CBM discharge permits within an irrigated drainage area, a watershed group will be assembled by WDEQ. The watershed group will consist of the following representatives:

- 1) Affected landowners
- 2) Resource expert(s) from one or more of the following: University of Wyoming School of Energy, UW Cooperative Extension, NRCS, Sheridan County Conservation District, Powder River Conservation District and/or Campbell County Conservation District;
- 3) CBM industry personnel
- 4) WDEQ regulatory staff

The watershed group will develop a Watershed Monitoring and Contingency Plan (WMCP), which shall consist of specified monitoring locations for outfalls, reservoirs, instream surface water sampling locations, groundwater monitoring wells, soil sampling sites and crop/forage monitoring sites. The WMCP will list the parameters to be monitored at each location, the respective monitoring frequencies, action threshold indicators and any actions necessary to correct or prevent crop production problems. In conjunction with the planning work of the watershed group, initial soil sampling will be conducted within the drainage. Where smectite-dominant soils are present in irrigated lands, the watershed group will adapt the WMCP accordingly to account for higher sensitivity to sodium. The WMCP will generally follow the recommendations contained in the technical advisory team report to WDEQ: “*Strategies, Monitoring and Data Needs for Preventing Impacts From Coal Bed Methane Produced Water to Crop and Forage Production in Wyoming*” (September 2010), as outlined for the various discharge scenarios included below.

#### Ongoing Review:

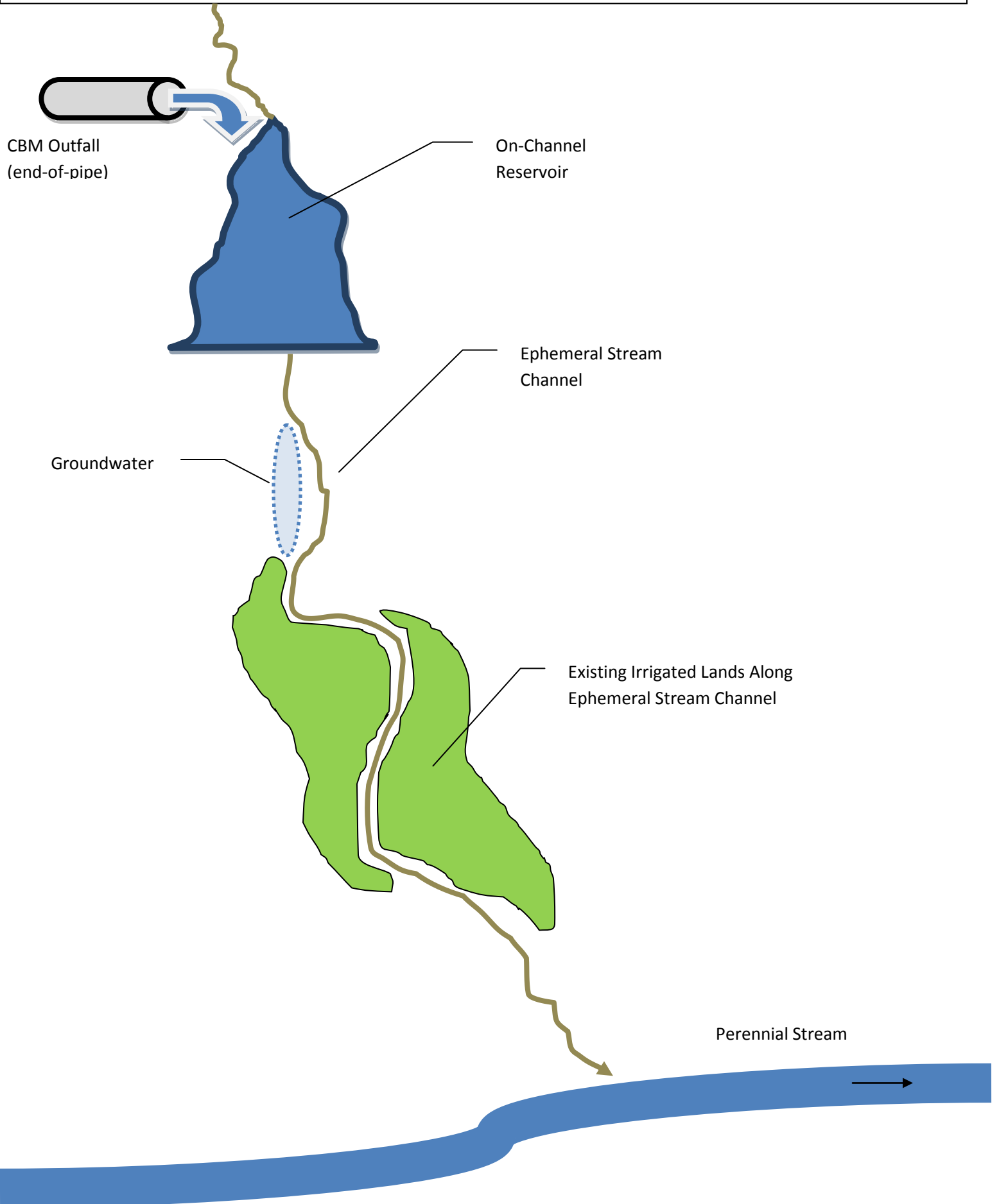
Watershed group and/or independent experts will meet annually to assess collected data and make recommendations to WDEQ and to affected landowners regarding CBM water management and water quality controls.

Adjustments to the WMCP will be made, as necessary, in order to adapt the monitoring and corrective actions to conditions on the ground.

#### Discharge Scenarios Subject to WMCP Planning and Review:

See Below.

**Scenario 1: Discharge to On-Channel Reservoir; Above Irrigated Lands on Ephemeral Stream**



## Scenario 1: Permit Requirements

### **Outfall:**



**Monitoring:** For first twelve months, monthly sampling for Electrical Conductivity (EC), sodium adsorption ratio (SAR), pH, bicarbonate ( $\text{HCO}_3$ ), flow. Quarterly sampling thereafter if constituents are below threshold levels.

**Threshold:** Effluent limits to protect livestock and wildlife. EC = 7500 micromhos/cm, pH = 6.5 – 9.0. Plus effluent limits for protection of downstream class 3 and class 2 waters.

**Corrective Action (If threshold exceeded):** WDEQ enforcement action.

### **Reservoir:**



**Monitoring:** For first twelve months, monthly sampling for EC, SAR, pH, bicarbonate, sulfates ( $\text{SO}_4$ ). Quarterly sampling thereafter if constituents are below threshold levels. Sample at least 5 feet from shoreline and at least 50 feet from CBM inlet. On select reservoirs, install staff gage. Monthly measurement of water elevation and stored volume within those reservoirs. Water volume data to be used for detailed water budgets within each drainage. Check for water re-surfacing below reservoir (flowing seeps).

**Threshold:** Flowing seep visible. Excessive salt build-up within reservoir = reservoir EC at 150% of average outfall EC or higher. Water release permitted if EC meets default crop threshold (USDA soil EC threshold / 1.5), and SAR meets Hanson 2006 formula. Additional SAR restrictions may apply if irrigated lands contain smectitic clays (clay fraction is 50% or greater smectite content).

**Corrective Action (If threshold exceeded):** If flowing seep appears below reservoir, then cease discharge at outfall, repair or close reservoir. If reservoir EC reaches or exceeds 150% of average outfall EC, then cease discharge and modify permit to eliminate outfall or require 50-year containment in reservoir.

## Scenario 1: Permit Requirements (continued)

### **Ephemeral Channel:**



**Monitoring:** Locate surface water monitoring stations below each reservoir series and near irrigated lands. Measure flow continuously near irrigated lands. Monthly flow at stations higher in the watershed. At all flowing stations, sample monthly for pH, EC, Ca, Mg, Na, K, SO<sub>4</sub>, HCO<sub>3</sub>, carbon isotopes.

**Threshold:** N/A

**Corrective Action (If threshold exceeded):** N/A

### **Groundwater:**



#### **Leakage From Ponds:**

**Site Selection:** Selective reservoir sampling, prioritize by highest risk (evaluate proximity of reservoir to fields, size of reservoir, underlying geology).

**Monitoring:** Monthly static water level year-round. Monthly water quality sampling during May, June July; Quarterly the rest of the year. Always sample and analyze for pH, EC, Ca, Mg, Na. Additional sampling for K, SO<sub>4</sub>, HCO<sub>3</sub>, Cl, carbon isotopes if under intensified monitoring. Groundwater monitoring wells subject to WDEQ guideline specifications for siting, installation, instrumentation, sampling and reporting.

**Threshold:** Evidence of lateral migration into stream channels, with groundwater flow toward irrigated fields.

**Corrective Action (If threshold exceeded):** Initiate continuous water level monitoring, using pressure transducer. Investigate source of groundwater flow, using intensified groundwater monitoring. Add monitoring wells if necessary; increase water quality sampling frequency if necessary. If CBM water is contributing to problematic groundwater elevations in downstream irrigated fields (see below), cease discharges from contributing outfalls.

## Scenario 1: Permit Requirements (continued)

### Shallow Groundwater Near Fields:

**Monitoring:** Quarterly static water level year-round. At least one continuous water level monitoring station per site, using pressure transducer. Quarterly water quality sampling. Always sample and analyze for pH, EC, Ca, Mg, Na. Additional sampling for K, SO<sub>4</sub>, HCO<sub>3</sub>, Cl, carbon isotopes if under intensified monitoring. Groundwater monitoring wells subject to WDEQ guideline specifications for siting, installation, instrumentation, sampling and reporting.

**Threshold:** First threshold = depth to groundwater less than 6 feet. Second threshold = depth to groundwater less than 3 feet.

**Corrective Action (If threshold exceeded):** If first threshold is triggered (depth to groundwater less than 6 feet), then investigation is needed to detect cause and corrective action. Evaluate upstream monitoring well data, intensify sampling in upstream monitoring wells and irrigated field monitoring wells, evaluate surface hydrology conditions in fields. If second threshold is triggered (depth to groundwater less than 3 feet), and the groundwater has a CBM water contribution, then cease contributing discharges.

### Soils:



**Site Selection:** Segment fields according to differences in soil characteristics or depth to groundwater. Look for distinct differences in EC (if using ground-based electromagnetic survey), texture, pH or vegetation. For each identified segment, minimum of one subsample per acre, but not less than 5 and not more than 15 subsamples per segment.

**Monitoring (initial):** 4 feet deep in grass fields. 6 feet deep if alfalfa present. Increments = 0-6", 6-12", then 12" each to depth. **Analyze for texture, clay mineralogy, exchangeable sodium percent (ESP), pH, EC, SAR, SO<sub>4</sub>, HCO<sub>3</sub>, lime, organic carbon (OC), N, P, K.** Composite within each identified soil segment, using co-located composited samples. On initial sampling, do not composite analysis for EC and pH. Analyze EC and pH on each individual subsample before compositing subsamples to run other analytes.

**Monitoring (ongoing):** 4 feet deep in grass fields. 6 feet deep if alfalfa present. Increments = 0-6", 6-12", then 12" each to depth. **Analyze for pH, EC, SAR, SO<sub>4</sub>, HCO<sub>3</sub>, chlorides (Cl).** Composite within each identified soil segment, using co-located composited samples. Annual fall sampling.

## Scenario 1: Permit Requirements (continued)

**Threshold:** Greater than 40% increase in EC or SAR in one year, or greater than 15% over two years or more. Regardless of trend, ESP greater than 10% or EC greater than 4,000 micromhos/cm at 0 -12” triggers corrective action below.

**Corrective Action (If threshold exceeded):** If any of the above thresholds is triggered, increase soil monitoring to twice per year (spring / fall). Initiate detailed study to identify cause of salt / sodium increase. If damage to soil is identified that is expected to impair crop / forage production, and damage is due to CBM discharges, then proceed with one or more of: curtailing contributing CBM discharges, changing discharge locations, providing improved drainage to fields, adding chemical amendments to fields.

### **Crops / Forage:**

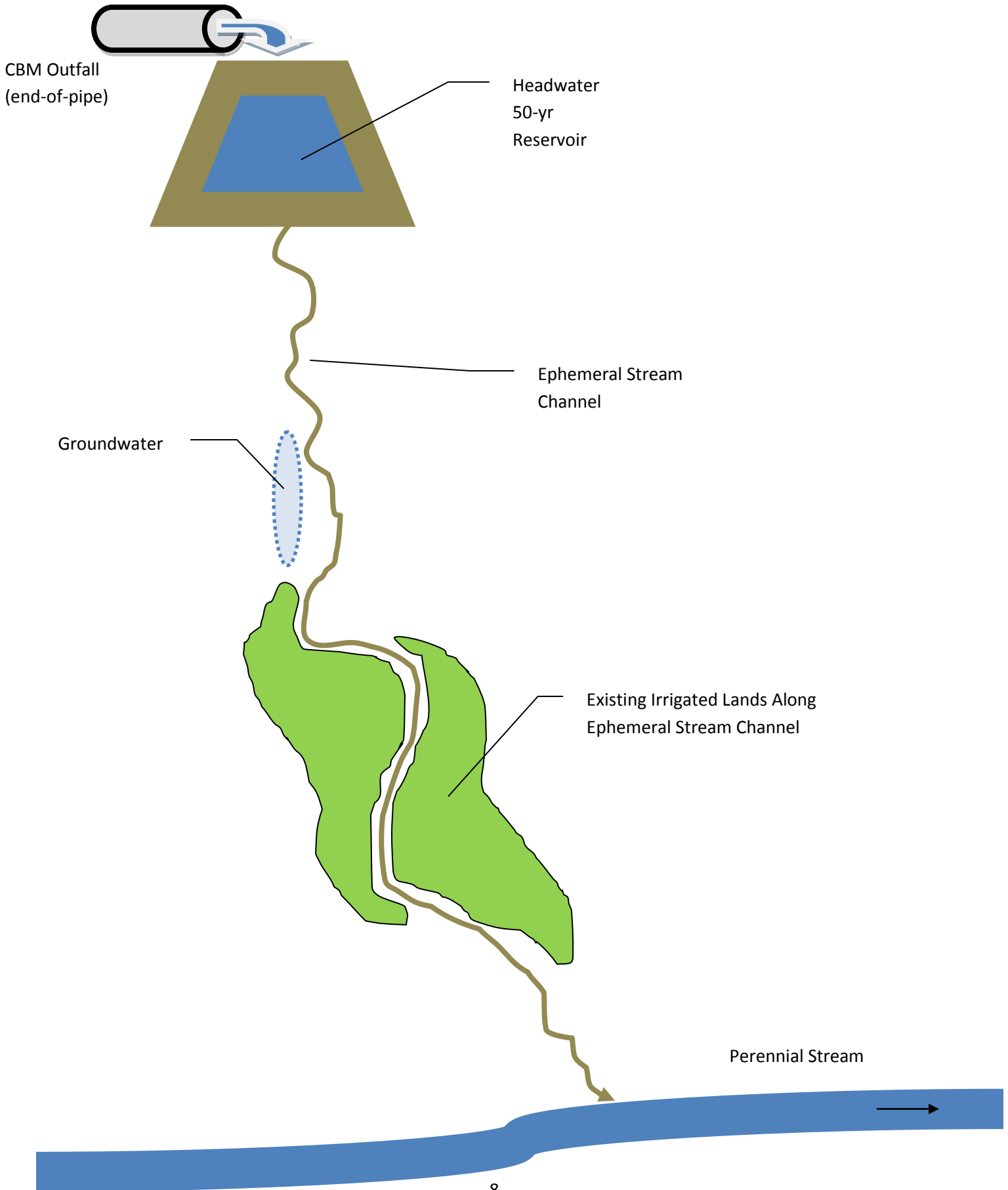


**Monitoring:** Vegetation sampling to occur in same areas as soil sampling. One square meter sample cuttings. Sample annual peak standing crop (late June – early July) or pre-cutting for hayed fields. Measure: yield (tons/acre), crude protein (CP), Ca, P, K, Se. Can use field harvest data for hay yield if available.

**Threshold:** Statistically significant decrease in yield or quality that correlates with causative mechanism such as soil water or groundwater impacts.

**Corrective Action (If threshold exceeded):** Reclamation of any damaged fields.

**Scenario 2:** Discharge to Headwater 50-yr Reservoir; Above Irrigated Lands on Ephemeral Stream



## Scenario 2: Permit Requirements

### **Outfall:**



**Monitoring:** Annual sampling for Electrical Conductivity (EC), sodium adsorption ratio (SAR), pH, bicarbonate ( $\text{HCO}_3$ ), flow.

**Threshold:** Effluent limits to protect livestock and wildlife. EC = 7500 micromhos/cm, pH = 6.5 – 9.0. Plus effluent limits for protection of localized class 3 stream as needed.

**Corrective Action (If threshold exceeded):** WDEQ enforcement action.

### **Headwater 50-yr Reservoir:**



**Monitoring:** For first twelve months, monthly sampling for EC, SAR, pH, bicarbonate, sulfates ( $\text{SO}_4$ ). Quarterly sampling thereafter if constituents are below threshold levels. Sample at least 5 feet from shoreline and at least 50 feet from CBM inlet. Install staff gage within all 50-yr reservoirs. Monthly measurement of water elevation and stored volume within the reservoirs. Water volume data to be used for detailed water budgets within each drainage. Check for water re-surfacing below reservoir (flowing seeps).

**Threshold:** Flowing seep visible below reservoir.

**Corrective Action (If threshold exceeded):** If flowing seep appears below reservoir, then cease discharge at outfall, repair or close reservoir.

## Scenario 2: Permit Requirements (continued)

### **Groundwater:**



### **Leakage From Ponds:**

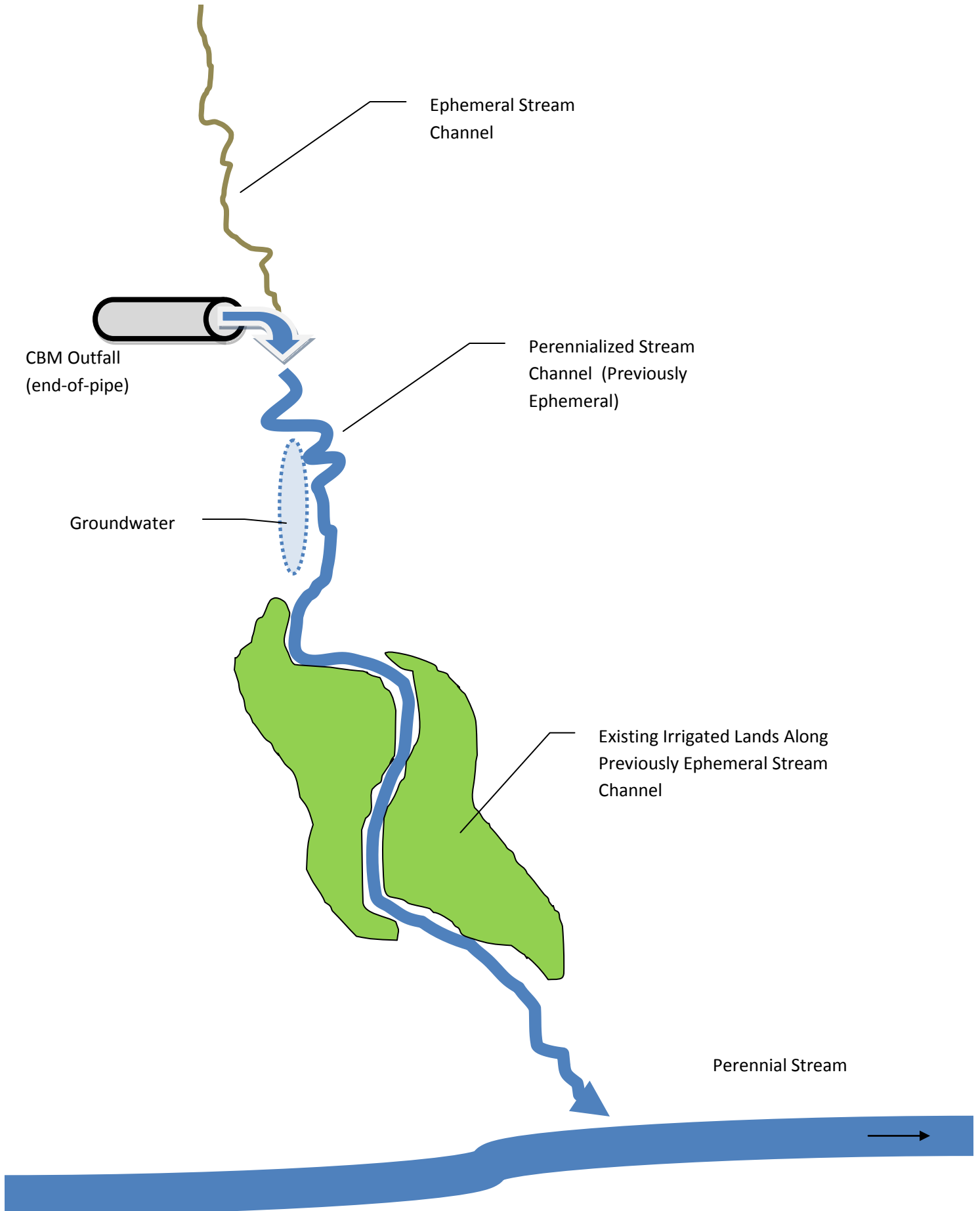
Site Selection: Selective reservoir sampling, prioritize by highest risk (evaluate proximity of reservoir to fields, size of reservoir, underlying geology).

Monitoring: Monthly static water level year-round. Monthly water quality sampling during May, June July; Quarterly the rest of the year. Always sample and analyze for pH, EC, Ca, Mg, Na. Additional sampling for K, SO<sub>4</sub>, HCO<sub>3</sub>, Cl, carbon isotopes if under intensified monitoring. Groundwater monitoring wells subject to WDEQ guideline specifications for siting, installation, instrumentation, sampling and reporting.

Threshold: Evidence of lateral migration into stream channels, with groundwater flow toward irrigated fields.

Corrective Action (If threshold exceeded): Initiate continuous water level monitoring, using pressure transducer. Investigate source of groundwater flow, using intensified groundwater monitoring. Add monitoring wells if necessary; increase water quality sampling frequency if necessary. If CBM water is contributing to problematic groundwater elevations in downstream irrigated fields, cease discharges from contributing outfalls.

**Scenario 3: Direct Discharge; Ephemeral Stream Becomes Perennialized**



## Scenario 3: Permit Requirements

### Outfall:



**Monitoring:** For first twelve months, monthly sampling for Electrical Conductivity (EC), sodium adsorption ratio (SAR), pH, bicarbonate ( $\text{HCO}_3$ ), flow. Quarterly sampling thereafter if constituents are below threshold levels. Continuous flow measurement.

**Threshold:** Default EC effluent limit for protection of downstream crop; EC limit to be derived from USDA salt tolerance database thresholds. EC limit will be calculated by dividing the published soil EC threshold value by 1.5. Where the published soil EC threshold is presented as a range of values, the median value of the range will serve as the published soil EC threshold. Limit SAR to  $< 6.67 \times \text{EC (dS/m)} - 3.33$ , where EC = actual measured EC of the sample. Limit SAR to a value between 3 and 10. Under circumstances where smectitic soils are present in the downstream irrigated lands (clay fraction is 50% smectite or greater), then additional restrictions may apply on SAR. EC and SAR effluent limits at outfall are subject to modification based upon results of downstream surface water monitoring. Limit discharge quantity to prevent inadvertent flooding of fields.

**Corrective Action (If threshold exceeded):** WDEQ enforcement action for exceedence of EC or SAR limits. Curtail direct discharge quantity if current discharges are causing inadvertent flooding of downstream fields.

### Perennialized Stream Channel



#### (Previously Ephemeral):

**Monitoring:** Locate surface water monitoring stations below outfall and near irrigated lands. Measure flow continuously near irrigated lands. Monthly flow at stations higher in the watershed. At all stations, sample monthly for pH, EC, Ca, Mg, Na, K,  $\text{SO}_4$ ,  $\text{HCO}_3$ , carbon isotopes.

**Threshold:** Instream threshold for EC to protect downstream crop; Instream EC threshold to be derived from background EC (where known), or USDA salt tolerance database thresholds. When using USDA salt tolerance values, instream EC threshold will be calculated by dividing the published soil EC threshold value by 1.5. Where the published soil EC threshold is presented as a range of values, the median value of the range will serve as the published soil EC threshold. Limit SAR to  $< 6.67 \times \text{EC (dS/m)} - 3.33$ , where EC = actual measured EC of the sample. Set instream SAR threshold between 3 and 10. Under circumstances where smectitic soils are present in the downstream irrigated lands (clay fraction is 50% smectite or greater), then

### Scenario 3: Permit Requirements (continued)

additional restrictions may apply on SAR. Limit discharge quantity to prevent inadvertent flooding of fields.

Corrective Action (If threshold exceeded): If instream EC or SAR threshold is exceeded over multiple months, then adjust outfall limits downward on contributing outfalls to account for instream increases; or eliminate contributing discharges.

#### **Shallow Groundwater Near Fields:**



Monitoring: Quarterly static water level year-round. At least one continuous water level monitoring station per site, using pressure transducer. Quarterly water quality sampling. Always sample and analyze for pH, EC, Ca, Mg, Na. Additional sampling for K, SO<sub>4</sub>, HCO<sub>3</sub>, Cl, carbon isotopes if under intensified monitoring. Groundwater monitoring wells subject to WDEQ guideline specifications for siting, installation, instrumentation, sampling and reporting.

Threshold: First threshold = depth to groundwater less than 6 feet. Second threshold = depth to groundwater less than 3 feet.

Corrective Action (If threshold exceeded): If first threshold is triggered (depth to groundwater less than 6 feet), then investigation is needed to detect cause and corrective action. Evaluate all available data from upstream surface water and groundwater monitoring locations, intensify sampling in irrigated field monitoring wells, possible add new wells to study subsurface connectivity of stream channel and groundwater below fields, evaluate surface hydrology conditions in fields. If second threshold is triggered (depth to groundwater less than 3 feet), and the groundwater has a CBM water contribution, then cease contributing discharges.

### Scenario 3: Permit Requirements (continued)

#### Soils:



**Site Selection:** Segment fields according to differences in soil characteristics or depth to groundwater. Look for distinct differences in EC (if using ground-based electromagnetic survey), texture, pH or vegetation. For each identified segment, minimum of one subsample per acre, but not less than 5 and not more than 15 subsamples per segment.

**Monitoring (initial):** 4 feet deep in grass fields. 6 feet deep if alfalfa present. Increments = 0-6", 6-12", then 12" each to depth. **Analyze for texture, clay mineralogy, exchangeable sodium percent (ESP), pH, EC, SAR, SO<sub>4</sub>, HCO<sub>3</sub>, lime, organic carbon (OC), N, P, K.** Composite within each identified soil segment, using co-located composited samples. On initial sampling, do not composite analysis for EC and pH. Analyze EC and pH on each individual subsample before compositing subsamples to run other analytes.

**Monitoring (ongoing):** 4 feet deep in grass fields. 6 feet deep if alfalfa present. Increments = 0-6", 6-12", then 12" each to depth. **Analyze for pH, EC, SAR, SO<sub>4</sub>, HCO<sub>3</sub>, chlorides (Cl).** Composite within each identified soil segment, using co-located composited samples. Annual fall sampling.

**Threshold:** Greater than 40% increase in EC or SAR in one year, or greater than 15% over two years or more. Regardless of trend, ESP greater than 10% or EC greater than 4,000 micromhos/cm at 0-12" triggers corrective action below.

**Corrective Action (If threshold exceeded):** If any of the above thresholds is triggered, increase soil monitoring to twice per year (spring / fall). Initiate detailed study to identify cause of salt / sodium increase. If damage to soil is identified that is expected to impair crop / forage production, and damage is due to CBM discharges, then proceed with one or more of: curtailing contributing CBM discharges, changing discharge locations, providing improved drainage to fields, adding chemical amendments to fields.

#### Crops / Forage:

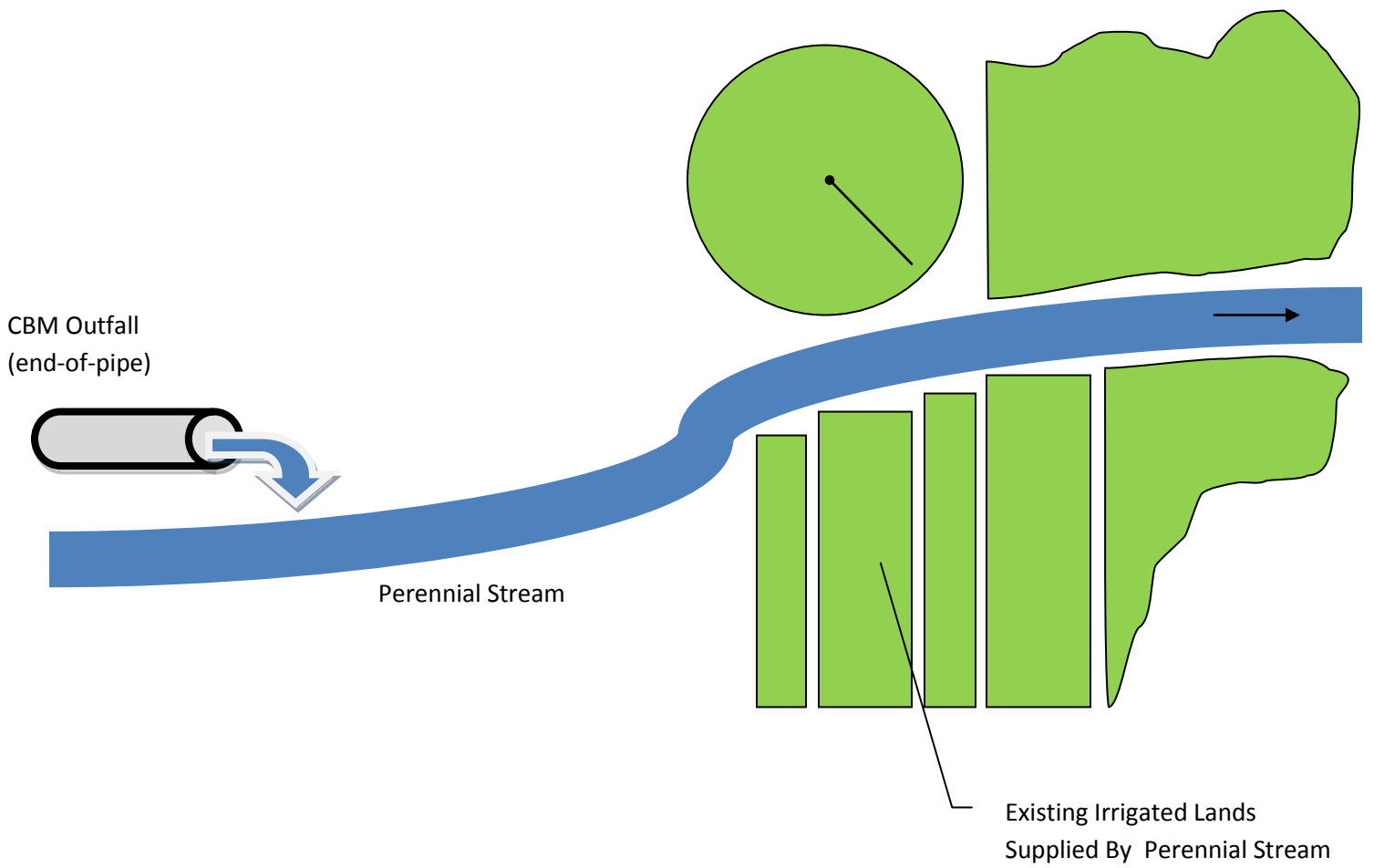


**Monitoring:** Vegetation sampling to occur in same areas as soil sampling. One square meter sample cuttings. Sample annual peak standing crop (late June – early July) or pre-cutting for hayed fields. Measure: yield (tons/acre), crude protein (CP), Ca, P, K, Se. Can use field harvest data for hay yield if available.

**Threshold:** Statistically significant decrease in yield or quality that correlates with causative mechanism such as soil water or groundwater impacts.

**Corrective Action (If threshold exceeded):** Reclamation of any damaged fields.

**Scenario 4: Direct Discharge to Perennial Stream**



## Scenario 4: Permit Requirements

### Outfall:



**Monitoring:** For first twelve months, monthly sampling for Electrical Conductivity (EC), sodium adsorption ratio (SAR), pH, bicarbonate ( $\text{HCO}_3$ ). Quarterly sampling thereafter if constituents are below threshold levels. Continuous flow measurement.

**Threshold:** Outfall effluent limits for EC and sodium to be calculated using waste load allocation. EC and sodium limits at outfall will be calculated based on historic median stream flow during the irrigation season, and shall apply during the irrigation season. Effluent limits for EC and sodium at outfall will be calculated to achieve instream targets outlined below.

**Corrective Action (If threshold exceeded):** WDEQ enforcement action.

### Perennial Stream Channel:



**Monitoring:** Monthly sampling upstream and downstream of outfall, plus at first point of irrigation diversion for pH, EC, Ca, Mg, Na, flow. If necessary for additional investigation, sample for K,  $\text{SO}_4$ ,  $\text{HCO}_3$ , Cl, carbon isotopes.

**Threshold:** Instream target EC will be derived using USDA salt tolerance database thresholds. When using USDA salt tolerance values, instream target EC will be calculated by dividing the published soil EC threshold value by 1.5. Where the published soil EC threshold is presented as a range of values, the median value of the range will serve as the published soil EC threshold. Where historic background EC in the perennial stream exceeds the above USDA crop threshold, the historic background EC will serve as the instream target. Instream SAR target will be  $< 6.67 \times \text{EC (dS/m)} - 3.33$ , where EC = actual measured EC of the instream sample. Set instream SAR target between 3 and 10. Under circumstances where smectitic soils are present in the downstream irrigated lands (clay fraction is 50% smectite or greater), then additional restrictions may apply on SAR and sodium.

**Corrective Action (If threshold exceeded):** If persistent exceedences of the instream thresholds for EC or SAR occur, investigate cause(s), including examination of non-point sources, stream flow data, other point sources within the basin. If CBM discharges are determined to be contributing to the exceedence of instream threshold(s) and crop/forage production is adversely affected, then modify EC and/or sodium limits downward to correct the problem, or curtail discharge quantity.

## Scenario 4: Permit Requirements (continued)

### Soils:



**Site Selection:** Segment fields according to differences in soil characteristics or depth to groundwater. Look for distinct differences in EC (if using ground-based electromagnetic survey), texture, pH or vegetation. For each identified segment, minimum of one subsample per acre, but not less than 5 and not more than 15 subsamples per segment.

**Monitoring (initial):** 4 feet deep in grass fields. 6 feet deep if alfalfa present. Increments = 0-6", 6-12", then 12" each to depth. **Analyze for texture, clay mineralogy, exchangeable sodium percent (ESP), pH, EC, SAR, SO<sub>4</sub>, HCO<sub>3</sub>, lime, organic carbon (OC), N, P, K.** Composite within each identified soil segment, using co-located composited samples. On initial sampling, do not composite analysis for EC and pH. Analyze EC and pH on each individual subsample before compositing subsamples to run other analytes.

**Monitoring (ongoing):** 4 feet deep in grass fields. 6 feet deep if alfalfa present. Increments = 0-6", 6-12", then 12" each to depth. **Analyze for pH, EC, SAR, SO<sub>4</sub>, HCO<sub>3</sub>, chlorides (Cl).** Composite within each identified soil segment, using co-located composited samples. Annual fall sampling.

**Threshold:** Greater than 40% increase in EC or SAR in one year, or greater than 15% over two years or more. Regardless of trend, ESP greater than 10% or EC greater than 4,000 micromhos/cm at 0 -12" triggers corrective action below.

**Corrective Action (If threshold exceeded):** If any of the above thresholds is triggered, increase soil monitoring to twice per year (spring / fall). Initiate detailed study to identify cause of salt / sodium increase. If damage to soil is identified that is expected to impair crop / forage production, and damage is due to CBM discharges, then proceed with one or more of: curtailing contributing CBM discharges, changing discharge locations, providing improved drainage to fields, adding chemical amendments to fields.

### Crops / Forage:



**Monitoring:** Vegetation sampling to occur in same areas as soil sampling. One square meter sample cuttings. Sample annual peak standing crop (late June – early July) or pre-cutting for hayed fields. Measure: yield (tons/acre), crude protein (CP), Ca, P, K, Se. Can use field harvest data for hay yield if available.

**Threshold:** Statistically significant decrease in yield or quality that correlates with causative mechanism such as soil water or groundwater impacts.

**Corrective Action (If threshold exceeded):** Reclamation of any damaged fields.