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Department of Natural Resources

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TO: Colorado Water Conservation Board Members

FROM: Ryan Gilliom (Colorado School of Mines), Tracy Kosloff (DWR), Kevin Reidy (CWCB)

DATE: September 6, 2019

AGENDA ITEM: 12. Rainwater Harvesting Pilot Projects: Updates to Criteria & Guidelines for Regional Factors

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Staff recommendation: Staff recommends that the Board adopt the proposed updates to the Rainwater Harvesting Pilot Project Criteria and Guidelines.

Background:

Rainwater harvesting pilot projects, described in subsection 37-60-115(6), C.R.S., can obtain operational approval using Regional Factors if such factors are approved by the board. In July 2019, the proposed Regional Factors were made available for public review and comment and the methodology was presented to the board. The revised Factors report and redlined pilot project Criteria and Guidelines are now presented to the board for approval.

Discussion:

The Regional Factors approach was presented at several industry group meetings and the materials were available for review on the DWR website. The public outreach presentations yielded a range of positive informal feedback about the Factors. Western Resource Advocates submitted a formal statement of support to Tracy Kosloff on July 31, 2019. We are hopeful the Factors decrease the perceived technical and financial barriers to investigate rainwater harvesting. The Board's feedback from the July 2019 meeting was incorporated into updates to the Factors report and updated Criteria and Guidelines as described below.

In response to Director Brown's concerns about the rock outcrop map and applicable area for Factors, the revised Criteria and Guidelines require applicants to submit a table of soil map unit areas from soil survey data; units that include "rock outcrop" in the soil description must be excluded from credit for historical natural depletion (HND). In response to Director Yahn's question about vegetation, the revised Criteria and Guidelines require applicants to submit on-site photos and/or historic aerial imagery to demonstrate the presence of vegetation prior to development at the site. Director Yahn also requested further investigation of the impact of slope angle on HND estimates; further research was conducted, which is discussed in Section 3 of the Regional Factors report.

The Criteria and Guidelines were updated to incorporate the proposed Factors, with text edits redlined in the attached version. The annual deadline to apply for pilot project approval was eliminated to increase flexibility of the program, given the low limit on total number of projects. The section describing use of Factors was updated to explain the concept, data, and application of the Factors. The annual review fee was reduced from $7,000 to $1,000 to reflect staff time and further reduce potential barriers to use of the program. Guidelines for landscaping and irrigation plans were updated to recommend irrigation and landscaping contractors that are certified by a USEPA WaterSense program. Additional text edits were made for clarity and consistency.

The Regional Factors Report was revised from the draft presented in July 2019. Updates were made in Section 1 (Introduction) and Section 2.4 (Map and Limitations of Factors Application), and Section 3.1.1.1 (Modeling Methods and Site Slope). Section 1 updates reframed the report as a document to support the proposed revisions to pilot project Criteria and Guidelines. Section 2.4 was updated to elaborate on soil and vegetation limitations in the use of the proposed Factors. Section 3.1.1.1 was updated with discussion of slope impacts on infiltration.

Ryan Gilliom, a DWR intern and PhD candidate at Colorado School of Mines, will present an overview of public feedback and updates to the Factors report and Criteria and Guidelines to address issues raised by the board in July. Tracy Kosloff will be present to answer questions on the pilot project operational approval process, and Kevin Reidy to address questions about water conservation and CWCB’s role in general.

COLORADO WATER CONSERVATION BOARD

Authorization of Pilot Projects for the Beneficial Use of Captured Precipitation in New Real Estate Developments Criteria and Guidelines for the "Rainwater Harvesting" Pilot Project Program,

Approved by CWCB: January 28, 2010

Amended by CWCB: January 26, 2016, September 18, 2019

INTRODUCTION

Purpose

The purpose of this document is to describe the Colorado Water Conservation Board ("CWCB" or "Board") process to implement the *Act Concerning an Authorization of Pilot Projects for the Beneficial Use of Captured Precipitation in New Real Estate Development, and Making an Appropriation in Connection Therewith,* as approved under House Bill (H.B.) 09-1129 and the *Act Concerning Incentives for Precipitation Harvesting, and, in Connection Therewith, Making an Appropriation,* as approved under H.B. 15-1016. House Bill 09-1129 calls for the Board to establish Criteria and Guidelines[1] for applications and the selection of pilot projects and for the Board, in consultation with the State Engineer, to select pilot project sponsors. CWCB staff developed Draft Criteria and Guidelines in consultation with the State Engineer and presented to the Board at its September 15, 2009 meeting, for informational purposes only. A technical advisory group provided comments on the draft, and updated Criteria and Guidelines were presented to and approved by the Board at its January 27, 2010 meeting. House Bill 15-1016 calls for the Board to update the Criteria and Guidelines[2] to allow for the establishment of Regional Factors that specify the amount of precipitation consumed through evapotranspiration of preexisting natural vegetative cover. The Division of Water Resources (DWR) staff and the CWCB staff presented the updated Criteria and Guidelines to the Board at its January 26, 2016 meeting and the Board approved the updated Criteria and Guidelines at that time. On July 17, 2019, DWR staff presented technical documentation for proposed Regional Factors to the Board. Revised Criteria and Guidelines incorporating the proposed Regional Factors were presented for Board approval at the September 18, 2019 meeting.

Background

Rainwater harvesting was not previously considered in Colorado primarily for two reasons: 1) historically relatively abundant and low-cost alternative water supplies have been available, and 2) prior to the passage of legislation in the 2008-2009 session, the law required 100% replacement of any precipitation captured out-of-priority, thereby requiring water users to find an equal amount of replacement water in like time and place. In 2007, a study entitled *Holistic Approach to Sustainable Water Management in Northwest Douglas County*[3] was published under the CWCB Water Efficiency Grant Program. The study emphasized the importance of pairing outdoor water management with rainwater harvesting to maximize water conservation potential. The study concluded that five main factors influence outdoor water demands:

1) amount of irrigated area,
2) landscaping material selection and corresponding water demand,
3) irrigation system performance, including sprinkler system efficiency and effects of installation, operations, and maintenance,
4) irrigation system technology such as rain gages and evapotranspiration controllers,
5) provider commitment and public acceptance.

Three outdoor water management strategies were considered, each based on an acceptable "look" of the landscaping to the public, as validated by the study advisory committee: (a) the traditional scenario included bluegrass with traditional plantings and spray irrigation; (b) the moderate scenario included fescue turf with a lower water demand than bluegrass, plantings classified as moderately consumptive, a portion of the potentially irrigated landscape was non-irrigated, and rotor irrigation; and (c) the water wise scenario included fescue turf with native plantings, an increase in non-irrigated areas, and subsurface drip irrigation.

Using historical hydrology data and commonly accepted quantification methods, the study concluded that with rainwater and snowmelt harvesting, outdoor water demand could be reduced by approximately 65% with "moderate conservation" and approximately 88% with "water wise conservation" as those scenarios were defined in the study. The study concluded that lawn and garden irrigation demands could be significantly reduced by using rainwater and snowmelt harvesting, particularly when paired with active water management techniques while maintaining a landscape appearance acceptable to Coloradoans. The study recommended statutory law be crafted to allow precipitation capture and use with augmentation requirements based on maintaining the amount, timing, and location of historical return flows (overland runoff and deep percolation). It also recommended a pilot project to verify the study conclusions, which were based on modeling the pairing of rainwater harvesting with efficient landscaping and irrigation practices.

The CWCB developed these Criteria and Guidelines, in consultation with the State Engineer, based on Section 37-60-115(6) of the Colorado Revised Statutes (C.R.S.), with input from a technical advisory group, and considering examples of data collection and reporting requirements utilized in rainwater harvesting projects in other states.[4] In 2016 and 2019, the CWCB, in consultation with the State Engineer, updated the Criteria and Guidelines with the goal of incentivizing Rainwater Harvesting Pilot Projects based on the revised language in Section 37- 60-115(6), C.R.S. that was adopted in H.B. 15-1016.[5]

RAINWATER HARVESTING PILOT PROJECT PROGRAM DEFINITION, GOALS, AND PURPOSES

H.B. 09-1129[6] addressed one of the recommendations from the *Holistic Approach to Sustainable Water Management in Northwest Douglas County* study with the authorization of up to ten pilot projects for new residential or mixed-use developments, providing an opportunity to further evaluate implementation of rainwater and snowmelt harvesting in Colorado (collectively referred to as "rainwater harvesting"). The CWCB defines rainwater harvesting pilot projects as:

> ***Rainwater harvesting pilot projects collect precipitation from rooftops and other impermeable surfaces and utilize the collected water for non-potable uses to evaluate water conservation potential. Pilot projects must be designed such that data collection***

> ***supports the purposes identified in Section 37-60-115(6)(a), C.R.S. and further evaluates water conservation potential through pairing rainwater harvesting with advanced[7] outdoor water demand management. Projects must be located in new residential or mixed-use development.[8]***
>
> ***Regional Factor is defined as one factor, or a set of factors, that specify the amount of precipitation consumed through evapotranspiration of preexisting natural vegetative cover in a specific region of the state.***

The goal of the pilot project program is to gain additional field-verified information about the feasibility of rainwater harvesting as a water conservation measure in Colorado, through pairing it directly with advanced outdoor water demand management – particularly efficient landscaping and irrigation practices. The purpose of the pilot projects, as described in Section 37-60-115(6)(a), C.R.S. shall be to:

(I) Evaluate the technical ability to reasonably quantify the site-specific amount of precipitation that, under preexisting, natural vegetation conditions, accrues to the natural stream system via surface and ground water return flows;

(II) Create a baseline set of data and sound, transferable methodologies for measuring local weather and precipitation patterns that account for variation in hydrology and precipitation event intensity, frequency, and duration, quantifying preexisting, natural vegetation consumption, measuring precipitation return flow amounts, identifying surface versus ground water return flow splits, and identifying delayed ground water return flow timing to receiving streams;

(III) Evaluate a variety of precipitation harvesting system designs;

(IV) Measure precipitation capture efficiencies;

(V) Quantify the amount of precipitation that must be augmented to prevent injury to decreed water rights;

(VI) Compile and analyze the data collected; and

(VII) Provide data to allow sponsors to adjudicate permanent augmentation plans as specified in paragraph (c) of this subsection (6).

The specific authorizing legislation for the pilot project program is attached. Specific data collection and reporting needed to meet the goal of the pilot project program are also provided under the Application Eligibility Requirements and Process and section below. The following Criteria and Guidelines have been developed pursuant to Section 37-60-115(6), C.R.S. and are adopted by the CWCB.

NOTE:

The Act limited the CWCB's ability to spend money to implement the Act. **As a result, only those applicants and the fees paid that fall within the Board's authorized spending authority shall be selected.** The CWCB indicated that the spending authority granted by H.B. 09-1129 would be a limiting factor in selecting and awarding projects. The Board will consider the need for the submission of a future budget Change Request if it determines such a request is needed.

APPLICATION ELIGIBILITY REQUIREMENTS AND PROCESS

These Criteria and Guidelines provide guidance for the pilot project application and approval process. As stated in the previous section, the goal of the pilot projects is to gain field-verified information about rainwater harvesting as a water conservation measure in Colorado, through pairing it directly with advanced outdoor water demand management. H.B. 09-1129 identified additional objectives toward advancing the understanding of potential water rights impacts from rainwater harvesting in Colorado. Rainwater harvesting pilot projects must operate according to a Substitute Water Supply Plan (SWSP) approved annually by the State Engineer pursuant to Section 37-92-308(4) or (5), C.R.S.

For the first two years of operation, sponsors of projects in areas where Regional Factors have not been adopted by the Board are required to replace an amount of water equal to the precipitation captured out-of-priority and measured from rooftops and impermeable surfaces. After a minimum of two years of implementation of rainwater harvesting applied to nonpotable uses with advanced outdoor water demand management and data collection, pilot project sponsors may apply to the appropriate water court for a permanent augmentation plan or file a plan with the State Engineer to permanently retire the rainwater collection system, which plan must be reviewed and approved prior to the cessation of augmentation. In the water court application for an augmentation plan, and in the associated SWSP, the sponsor may apply to reduce the augmentation obligation by an amount equal to the historical consumptive use from preexisting, natural vegetation cover. The minimum two year data collection period begins once water collected through rainwater harvesting, under an approved SWSP, is applied to nonpotable demands in combination with additional demand management.

Sponsors of projects in areas where Regional Factors have been adopted by the Board may propose to use the Regional Factor to claim an evapotranspiration credit for the preexisting vegetative cover that was made impermeable through development associated with the pilot project. The evapotranspiration credit may be used prior to the sponsor completing two years of data collection and/or the sponsor's application to the water court. Proposed use of the credit will be reviewed as a part of the State Engineer's SWSP approval process.

The CWCB, in consultation with the State Engineer, shall consider all Eligibility Requirements, as described below, in evaluating pilot project proposals. As required under Section 37-60-115(6)(b)(V), C.R.S., **priority shall be given to projects that a) are located in areas that face renewable water supply challenges and b) promote water conservation.** Approval for an SWSP[9] and water court decree is a separate process and is not explicitly addressed in these Criteria and Guidelines.

Eligibility Requirements

For an applicant to be eligible for the pilot project program, it must meet the requirements described in this section. Only projects associated with new development are eligible; no applications for existing structures or development will be considered. Proposals for rainwater harvesting pilot projects must include:

1. Pilot project sponsor information including:
    a. The name and contact information of the pilot project sponsor.
    b. A description of how the pilot project sponsor qualifies as an applicant for a new development as defined in Section 29-20-103, C.R.S., for a new planned unit development or new subdivision of residential housing or mixed uses.

   c. A list of the organizations and/or individuals including those hired or otherwise retained by the entity that will assist in development and implementation of the pilot project and analysis of data, including a written statement of their role and contributions and any applicable professional licensing/certifications (e.g. licensed professional engineer, plumber, landscape irrigation designer, etc.). Applicant must demonstrate its commitment to carrying out the goals of the pilot project through demonstrating adequate staffing (paid or volunteered, in-house or outsourced, consultants, advisors, etc.) and a commitment to make the applicant's resources available to carry out the pilot project.

2. An application fee of $4,000 and demonstration of ability to provide an annual review fee of $1,000 throughout the pilot project, per Section 37-60-115(6)(b)(I), C.R.S. H.B. 09- 1129 limited the CWCB's ability to spend money to implement the Act. **As a result, only those applicants and the fees paid that fall within the Board's authorized spending authority shall be selected.** The CWCB indicated that the spending authority granted by H.B. 09-1129 would be a limiting factor in selecting and awarding projects. The Board will consider the need for the submission of a future budget Change Request if it determines such a request is needed. The annual review fee will be due one year after acceptance as a pilot project.

3. A description of the proposed new development, per Section 37-60-115(6)(b)(II), C.R.S., including:
   a. Description of the current conditions of the project site and watershed. Aerial photo of pilot project site and at least 3 on-site photos showing extent of native vegetation.
   b. Project location map, including identification of location within a Water Division as established in Section 37-92-201, C.R.S., watershed boundaries, location of rainwater catchment area and site where rainwater is applied to nonpotable uses, location of climate data measurements, and other pertinent geographic and hydrologic information, per Section 37-60-115(6)(b)(III), C.R.S. Map of hydrologic soil group map units in the pilot project catchment, including tabulated area of units named with "rock outcrop" (see Rainwater Harvesting Pilot Project Regional Factors Report (2019) for further details),

4. A description of the proposed rainwater harvesting collection system, per Section 37-60-115(6)(b)(II), C.R.S., including:
   a. Description of the collection system sizing, design, and maintenance plan.
   b. Estimated average volume of water to be captured each month, based on historical precipitation data.
   c. Method for metering inflow and measuring capture efficiencies.

5. A description of how the proposed development meets any applicable local government water supply requirement through sources other than precipitation harvesting, per Section 37-60-115(6)(b)(IV), C.R.S.

6. A description of renewable water supply challenges for the area, per Section 37-60-

115(6)(b)(V)(A), C.R.S. Indicate how the proposed project addresses key water needs, for example, as identified in the Colorado Water Plan or associated documents and offers opportunity to collect information from a variety of geographic and hydrologic areas throughout the state. Preference may be given to projects that address larger water supply needs or in locations with critical water supply challenges.

7. A description of the pilot project implementation plan and how the project will promote and implement water conservation, per Section 37-60-115(6)(b)(V)(B), C.R.S., including:
   a. Description of how rainwater harvesting will be utilized on-site and paired with advanced outdoor water demand management techniques to promote water conservation, including:
      i. Landscape and irrigation design approach and specific advanced outdoor water demand management practices to be utilized.
      ii. The implementation plan shall provide for metering of all on-site landscape water (harvested rainwater and any supplemental potable water supply) and address any potential cross-connection issues and backflow prevention if the rainwater harvesting system is connected to a backup potable water supply.
      iii. Irrigation system technology to promote water conservation.
      iv. Homeowner/community water conservation education approach.
   b. Description of metrics that will be used to quantify water usage and an estimate of the projected water savings through rainwater harvesting paired with advanced outdoor water management techniques. These shall include but not be limited to:
      i. Landscape plans and water budgets including square footage of irrigated and non-irrigated landscape for common areas and individual homes, description and quantification of landscape plantings, estimated average annual demand in gallons per square foot based on historical evapotranspiration rates (water budgets). Landscape plans should follow industry best practices.
      ii. Design plans of irrigation systems including, but not limited to, emitter types, controller type, rain sensor and meter type for measuring use of water from the rainwater harvesting collection system and any supplemental potable water supply. A system-wide irrigation audit should be performed within the first season of operation and action taken to address findings. Irrigation design plans should be carried out by an irrigation designer and contractor certified through a program labeled by the U.S. Environmental Protection Agency's WaterSense program.
      iii. Landscape management plan to include irrigation schedule, maintenance schedules, and other ongoing management aspects. Landscape management should be carried out by a contractor who is certified through a program labeled by the U.S. Environmental Protection Agency's

WaterSense program.

iv. Connection(s) between the rainwater harvesting collection system and irrigation system should be fully metered. At a minimum, sponsors shall consider automated meter reading/data loggers with immediate feedback to pilot project sponsors on impacts from water management decisions.

v. Description of homeowner/community water conservation education campaign and training program (i.e. how will the pilot project sponsor support and assist homeowners, community members, and maintenance personnel to make the best water management decisions). These educational programs should be comprehensive to include indoor and outdoor water demand management, water supply, and water quality education.

c. Estimated pilot project costs including:

i. Estimated infrastructure and ongoing operations and maintenance costs associated with implementing the system, and

ii. Estimated cost to implement project per acre-foot of water saved. Considerations should include: institutional, legal, technical/design, infrastructure, and augmentation water supply. Potential cost savings and benefits associated with the project should also be quantified: reduced water rights acquisition, reduced storm water system sizing, water quality benefits, etc.

d. Pilot project implementation schedule for all major project components and data collection. The minimum two year data collection period (without credit for historical natural depletion if not using Regional Factors) begins once water collected through rainwater harvesting, under an approved SWSP, is applied to nonpotable demands in combination with advanced outdoor demand management. A project sponsor must make a commitment to implement some level of data collection within the first year of receiving approval as a pilot project.

8. A description of how the rainwater harvesting pilot project will meet the purposes of the rainwater harvesting pilot program per Section 37-60-115(6)(a), C.R.S. Data collection, reporting, and analysis methods may include but not be limited to:

a. Determining local weather and precipitation patterns that account for variations in hydrology and precipitation event intensity, frequency, and duration.

b. Quantifying preexisting, natural vegetation consumption.

c. Measuring precipitation return flow amounts.

d. Identifying surface water versus ground water return flow splits.

e. Identifying delayed ground water return flow timing to receiving streams.

f. Quantifying the amount of precipitation that must be augmented to prevent injury to decreed water rights.

g. Utilization of a Regional Factor

9. A summary of an SWSP application that demonstrates the applicant can meet the requirements of the *General Guidelines for Substitute Water Supply Plans Submitted to the State Engineer Pursuant to Section 37-92-308, C.R.S. (2003).*

   a. For pilot projects that are not using Regional Factors, the summary shall contain, at a minimum, an explanation of how the applicant will engage resources necessary to determine 1) the maximum amount of precipitation that will be captured during the year, 2) the timing with which that entire amount of precipitation would accrue to the stream system through overland flow and deep percolation, 3) the potential sources of replacement water that will be available to replace those depletions at the appropriate locations, and 4) how the plan will be operated.

   b. For pilot projects that are using Regional Factors, the summary shall describe if the project will result in any out-of-priority depletions due to the storage of water in excess of the historic natural depletion, and if so describe the potential sources of replacement water that will be available to replace those depletions at the appropriate locations. The summary shall also describe how the replacement plan will be operated.

   c. The CWCB will not consider a pilot project for selection if, in consultation with the State Engineer, it determines that the applicant does not have the resources to develop a viable SWSP for approval. The SWSP process for pilot projects and unique requirements for rainwater harvesting SWSPs are detailed in the State Engineer's Rainwater Harvesting Legal Framework memo (2019).

Process

Section 37-60-115(6), C.R.S. establishes certain processes and obligations for pilot project sponsors as well as the CWCB, in consultation with the State Engineer, as further described in this section. H.B. 09-1129 limited the CWCB's ability to spend money to implement the Act. **As a result, only those applicants and the fees paid that fall within the Board's authorized spending authority shall be selected.** The CWCB indicated that the spending authority granted by H.B. 09-1129 would be a limiting factor in selecting and awarding projects. The Board will consider the need for the submission of a future budget Change Request if it determines such a request is needed.

A. Pilot Project Sponsors

i. Prospective pilot project sponsors shall submit proposals meeting the Eligibility Requirements described above, along with the application fee, to the CWCB. Per Section 37-60-115(6)(b)(III), an applicant that meets the Eligibility Requirements may apply to become a sponsor of one or more of the ten pilot projects, however no more than three pilot projects may be located within any single Water Division established in Section 37-92-201, C.R.S.

ii. Pilot projects authorized by the Board may begin collecting rainwater upon approval of an SWSP. Pilot project sponsors must operate according to an SWSP[10], if approved annually by the State Engineer pursuant to Section 37-92-308(4) or (5), C.R.S.

iii. Pilot project sponsors shall provide an annual preliminary report to the Board and State Engineer throughout the term of the pilot project, until a water court decree is obtained or a cessation plan is approved by the State Engineer, per Section 37-60- 115(6)(d), C.R.S. Annual reports and review fees shall be due annually on July 1, unless otherwise authorized by the CWCB. Annual reports shall summarize the information set forth in Section 37-60-115(6)(a), C.R.S. and indicate how data and findings address the pilot project program goals, including:

a) Variances from original project as conceptualized at the time of the pilot project program application. Include information on any data quality issues that may be magnified if results are extrapolated to a larger scale project.

b) Rainwater harvesting system performance, including:

- Description of final collection system design with plans and specifications of all system components;
- Operations and maintenance plans and any issues encountered;
- Metered amount of water flowing into the rainwater collection device (hourly or daily with automated meter reading/data logger or equivalent) and estimated capture efficiency;

c) Pilot project implementation plan and estimated water conservation achieved through pairing rainwater harvesting with advanced outdoor water management, including:

- Description of method of applying captured rainwater and any supplemental potable water supply (e.g. drip system, sprinkler, etc). with plans and specifications for all system components including technology such as irrigation system programmers, evapotranspiration controllers, etc.;
- Landscaping plans including measured irrigated areas, plant descriptions, theoretical irrigation water requirement methods and results, and water budget reflecting application efficiencies;
- Metered water use diverted from the rainwater collection system (hourly or daily with automated meter reading/data logger or equivalent) and use by category if application varies (e.g. different irrigation systems);
- Metered water use from other potable water supply sources (hourly or daily with automated meter reading/data logger or equivalent) if rainwater is supplemented;
- Comparison of actual consumptive use by category of use to estimated water budgets and estimate of water conserved as a result of the rainwater harvesting;
- Landscape maintenance assessment (i.e. quality of landscape, maintenance issues, replacement plantings), and irrigation system audit results and corresponding actions.
- Costs including design, infrastructure, operations, and maintenance

costs; estimated cost to implement rainwater harvesting system per acre-foot of water saved; and comparison of original projected and actual costs from implementing rainwater harvesting systems. Considerations should include: institutional, legal, technical/design, infrastructure, and augmentation water supply.

d) A review of the project's hydrologic data collection and analysis plan including a discussion of how the plan addresses the pilot project program goals and a summary of the accomplished and planned tasks.

- Discuss how the project, as completed to date and planned going forward, creates a baseline data set and sound, transferable methodologies that meet the following objectives (at sites using Regional Factors some of the following items are estimated and not directly measured, but applicants should describe how they would be measured or identified to develop a permanent augmentation plan):
    - Measure local weather and precipitation patterns that account for variation in hydrology and precipitation event intensity, frequency, and duration to Quantify preexisting, natural vegetation consumption
    - Measure precipitation return flow amounts
    - Identify surface versus ground water return flow splits
    - Identify delayed ground water return flow timing to receiving streams
    - Quantify the amount of precipitation that must be augmented to prevent injury to decreed water rights.
    - Apply the data set toward the adjudication of a permanent augmentation plan
- Provide an update of the collection and analysis of data, including a description of how the sponsor will quantify the site-specific amount of precipitation that accrues to the stream system, via surface water and ground water, under preexisting, natural conditions.
    - If the sponsor is using a Regional Factor for the purposes of the pilot project and associated SWSPs, describe how hydrologic data about preexisting natural conditions that is necessary for the purposes of adjudicating a permanent augmentation plan will be collected.

iv. All program descriptions should include a description of the location and method of collecting daily or more frequent climate data measurements, with a summary of data including, at a minimum, temperature and precipitation.

v. Pilot project sponsors shall submit a final report to the CWCB and State Engineer by January 15, 2025, or the appropriate date if extended, per Section 37-60-115(6)(d), C.R.S. Final reports shall include a compilation of annual reports and a summary of project findings and conclusions including variations from the pilot project as conceptualized at the time of application to the pilot project program.

B. Colorado Water Conservation Board

i. Applications for rainwater harvesting pilot projects will be accepted on a rolling basis.

ii. CWCB staff, in consultation with the State Engineer, shall have up to 120 days to review and evaluate pilot project proposals, according to the Eligibility Requirements previously described. Pilot project applications that meet the Eligibility Requirements will be placed on the agenda for the next available Board meeting following the 120 day review period.

iii. CWCB staff shall present recommendations to the Board for consideration at the next available Board meeting following the 120 day review period, at which time the Board may approve, disapprove, or defer a decision to award a pilot project. Board approval will be contingent to SWSP approval, per Section 37-60-115(6)(c), C.R.S.

iv. The CWCB and the State Engineer shall brief the Water Resources Review Committee created in Section 37-98-102, C.R.S., on the reported results of the pilot projects by July 1, 2014 and shall provide a final briefing to the Water Resources Review Committee by July 1, 2025, per Section 37-60-115(6)(d), C.R.S.

Regional Factors

Paragraph (b) of subsection (6) of Section 37-60-115, C.R.S. directs the Board to develop Regional Factors that sponsors may use in SWSPs obtained as a part of a pilot project.

A. Development of Regional Factors

i. The Board need not adopt a Regional Factor until a sponsor has collected a minimum of two years of data and has submitted the data to the Board.[11][12] For the purposes of developing Regional Factors only, two years of data collection shall include, at a minimum, stream gage and evapotranspiration data from the development site; data collection may start before the rainwater is applied to non-potable demands.

ii. Once the Board receives the sponsor's data, the State Engineer, in consultation with the CWCB, shall review the data and propose one factor, or a set of factors, for adoption by the Board and inclusion into these Criteria and Guidelines as the Regional Factor. All proposed Regional Factors submitted to the Board for inclusion to the Criteria and Guidelines shall include, at a minimum:

iii. A map of the region where the Regional Factor will be applied,

iv. A description of the data collected by the sponsor,

v. A description of the methodology used to develop the proposed Regional Factor,

vi. A description of the proposed Regional Factor and any limitations of use,

vii. Draft updated Criteria and Guidelines that incorporate the proposed Regional Factor into this section of the Criteria and Guidelines.

B. Use of Regional Factors

i. If a sponsor submits an application in a region where Regional Factors have been adopted under these Criteria and Guidelines, the sponsor may propose the use of the Regional Factors in SWSPs applied for pursuant to section 37-92-308(4) or (5), C.R.S. and associated with the sponsor's pilot project. The State Engineer shall give the sponsor's use of the Regional Factors in said SWSP applications a presumptive effect, subject to rebuttal.[12]

ii. One set of Factors was adopted by the Board in 2019. The complete documentation of those Factors and their use is included in Attachment A, the Regional Factors Report (2019). The following summarizes this set of Factors and their use:

iii. **Concept.** Allowed rainwater harvesting volumes are estimated using three calculations that require NRCS Hydrologic Soil Group information for the catchment area. The infiltration factor is the percentage of a precipitation event that infiltrates, which varies from 25 to 90 percent based on the soil group and the precipitation depth and duration. The groundwater factor is the percentage of a precipitation event that is a groundwater return flow, which varies from 3 to 6 percent, depending on the soil group. The ET/Soil factor is a 30-day limit on the rainwater harvesting volume, which varies depending on the month of the year.

iv. **Data.** Use of Factors requires quantification and documentation of area made impervious in the development, area of NRCS Hydrologic Soil Groups A, B, C, & D, and on-site precipitation monitoring with 15-minute resolution.

v. **Accounting.** The Factors accounting process requires use of a daily accounting spreadsheet using the template provided by DWR. The template applies the three calculations described above. The user inputs the 15-minute precipitation record, which is processed into individual storms. The accounting sheet uses event depth and duration and soil group information to determine the volume of historic natural depletion. The sheet is also used to maintain storage accounting with all gains and losses to assure accurate tracking of the volume of runoff harvested and any out-of-priority depletions. Lastly, the accounting tracks any replacement water provided to the stream for out-of-priority depletions.

All approved applications and reporting under pilot projects will become public record and will be available to the public through the CWCB website. These Criteria and Guidelines do not attempt to provide guidance on the level of detail in data collection/analysis needed to successfully advance a pilot project through the SWSP process or water court. It is anticipated that such requirements may vary depending on the size and type of rainwater harvesting

system, project location, and resulting impact on the stream system. It is the pilot project sponsor's responsibility to propose the appropriate level of detail, subject to review and approval by the State. Further, compliance with these Criteria and Guidelines does not ensure an SWSP or water court application will be approved. These Criteria and Guidelines shall be reviewed and updated as necessary.

[1] Per Section 37-60-115(6)(b), C.R.S., the board shall establish criteria and guidelines for applications and the selection of pilot projects, including the following:

- (I) An application fee and, for pilot projects that are selected, an annual review fee;
- (II) The information to be included in the application, including a description of the proposed development and the proposed precipitation harvesting system;
- (III) Selection of pilot projects to represent a range of project sizes and geographic and hydrologic areas in the state, with no more than three pilot projects being located within any single water division established in section 37-92-201;
- (IV) The requirement that the proposed development meet any applicable local government water supply requirements through sources other than precipitation harvesting;
- (V) Giving priority to pilot projects that:
  - (A) Are located in areas that face renewable water supply challenges; and
  - (B) Promote water conservation.

[2] Per Section 37-60-115(6)(b), C.R.S., as amended by H.B. 15-1016, the board shall update the criteria and guidelines with the goal of incentivizing the submission of applications and applying lessons learned from previously approved pilot projects for applications and the selection of pilot projects, including the following:

- (VI) Regional Factors that sponsors can use for Substitute Water Supply Plans that specify the amount of precipitation consumed through evapotranspiration of preexisting natural vegetative cover. If an applicant uses the factors, the State Engineer shall give the factors presumptive effect, subject to rebuttal. The Board need not establish factors for a region until the sponsor of a project located within that region has submitted a minimum of two years of data pursuant to sub-subparagraph (B) of subparagraph (II) of paragraph (C) of this subsection (6). A sponsor that makes such a submission shall also submit the data to the Board.

[3] *Holistic Approach to Sustainable Water Management in Northwest Douglas County*, Prepared by Leonard Rice Engineers, Inc., Meurer & Associates, and Ryley, Carlock & Applewhite for the Colorado Water Conservation Board, Dominion Water and Sanitation District, Castle Pines North Metropolitan District, Douglas County, Thunderbird Water and Sanitation District, and Plum Valley Heights HOA, January 2007.

[4] *The Texas Manual on Rainwater Harvesting, Third Edition,* Texas Water Development Board, 2005. Dr. Hari J. Krishna, Contract Manager; *Rainwater Harvesting: Supply from the Sky,* City of Albuquerque, March 1995; *Approval of Rainwater Harvesting Systems as a Statewide Alternate Method of Providing Water for Non-Potable Uses,* State of Oregon Building Codes Division, Alternate Method Ruling No. OPSC 08-03; *Ordinance No. 10597 and Development Standard No. 10-03.0 Commercial Rainwater Harvesting,* City of Tucson, April 2009.

[5] The rainwater harvesting pilot project program updated under H.B. 15-1016 requires the Board to update the Rainwater Harvesting Pilot Project Criteria and Guidelines by January 1, 2016 with the goal of incentivizing the submission of applications and applying lessons learned from previously approved pilot projects. The primary method of incentive identified by H.B. 15-1016 is the Board's adoption and of Regional Factors for the evapotranspiration of preexisting vegetative cover.

[6] The rainwater harvesting pilot project program established under H.B. 09-1129 is separate from Senate Bill 09-80 which authorized limited exemptions for water collected from certain residential rooftops that are served by wells permitted for domestic uses according to Section 37-92-602, C.R.S., and meeting other criteria described under S.B. 09-80.

[7] CWCB considers advanced outdoor water demand management to include concepts similar to those identified in the *Holistic Approach to Sustainable Water Management in Northwest Douglas County* that reduce outdoor water demands and improve application efficiency.

[8] Per 37-60-115(6)(b), an applicant for a development permit, as that term is defined in Section 29-20-103, C.R.S., for a new planned unit development or new subdivision of residential housing or mixed uses may submit an application the Board to become a sponsor of one or more of the ten pilot projects. Section 29-20-103, C.R.S. indicates that a development permit is generally limited to an application regarding a specific project that includes new water use in an amount more than that used by fifty single-family equivalents, or fewer as determined by the local government.

[9] For additional information, see Rainwater Harvesting Legal Framework Memo (2019), Division of Water Resources Policy 2003-2, Implementation of Section 37-92-308, *CRS (2003) Regarding Substitute Water Supply Plans, and the Attachment to Policy 2003-2, General Guidelines for Substitute Water Supply Plans Submitted to the State Engineer Pursuant to Section 37-92-308, C.R.S. (2003).*

[10] The following State Engineer approval is described in Section 37-60-115(6)(c), C.R.S.: Notwithstanding any limitations regarding phreatophytes or impermeable surfaces that would otherwise apply pursuant to Section 37-92-103 (9) OR 37-92-501(4) (b) (III), each of the ten pilot projects shall:

(I) During the term of the pilot project, operate according to a substitute water supply plan, if approved annually by the state engineer pursuant to section 37-92-308 (4) or (5). The pilot project shall be required to replace an amount of water equal to the amount of precipitation captured out of priority from rooftops and impermeable surfaces for nonpotable uses; except that, in determining the quantity of water required for the Substitute Water Supply Plan to replace out-of-priority stream depletions, there is no requirement to replace the amount of historic natural depletion to the waters of the state, if any, caused by the preexisting natural vegetative cover evapotranspiration for the surface areas made impermeable and associated with the pilot project. The applicant bears the burden of proving the historic natural depletion; except that the applicant may use the applicable regional factors established pursuant to subparagraph (V) of paragraph (b) of this section. (II)

(A) Apply to the appropriate water court for a permanent augmentation plan prior to completion of the pilot project or file with the state engineer to permanently retire the rainwater collection system, which plan shall be reviewed and approved prior to the cessation of augmentation. As a condition of approving retirement of a pilot project, the state engineer shall have the authority to require the project sponsor to replace any ongoing delayed depletions caused by the pilot project after the project has ceased. Any such permanent augmentation plan shall entitle the sponsor to consume without replacement only that portion of the precipitation that the sponsor proves by a preponderance of the evidence would not have accrued to the natural stream under preexisting, natural vegetation conditions. The sponsor shall be required to fully augment any precipitation captured out of priority that would otherwise have accrued to the natural stream.

(B) After a minimum of two years of data collection and upon application to the appropriate water court for a permanent augmentation plan, the pilot project sponsor shall file an application for approval of a substitute water supply plan pursuant to section 37-92-308 (4). For any substitute supply plan application filed under section 37-92-408(4), the sponsor shall fully augment an precipitation captured out of priority; except that, in determining the quantity of water required for the Substitute Water Supply Plan to replace out-of-priority stream depletions, there is no requirement to replace the amount of historic natural depletion to the waters of the state, if any, caused by the preexisting natural vegetative cover evapotranspiration for the surface areas made impermeable and associated with the pilot project. The applicant may use applicable regional factors established pursuant to subparagraph (V) of paragraph (b) of this subsection (6).

[11] Per Section 37-60-115(6)(b)(VI), C.R.S., the board shall update the criteria and guidelines to include Regional Factors that sponsors can use for Substitute Water Supply Plans that specify the amount of precipitation consumed through evapotranspiration of preexisting natural vegetative cover. If an applicant uses the factors, the State Engineer shall give the factors presumptive effect, subject to rebuttal. The Board need not establish factors for a

region until the sponsor of a project located within that region has submitted a minimum of two years of data pursuant to sub-subparagraph (B) of subparagraph (II) of paragraph (C) of this subsection (6). A sponsor that makes such a submission shall also submit the data to the Board.

[12] Sections 37-92-308(4)(a)(IV)(B) and 37-92-308(5)(IV)(B), C.R.S., state that:

> Notwithstanding an limitations regarding phreatophytes or impermeable surfaces that would otherwise apply pursuant to section 37-92-103(9) or 37-92-501(4)(b)(III), for any precipitation harvesting pilot project selected pursuant to section 37-60-115(6), the applicant shall fully augment any precipitation captured out of priority; except that, in determining the quantity of water required for the substitute water supply plan to replace out-of-priority stream depletions, there is no requirement to replace the amount of historic natural depletion to the waters of the state, if any, caused by preexisting natural vegetative cover evapotranspiration for the surface areas made impermeable and associated with the pilot project. The applicant may use regional factors established pursuant to section 37-60-115(6)(b)(VI).

In addition, Section 37-60-115(6)(b)(VI) states that:

> If the applicant uses the [regionally applicable] factors, the State Engineer shall give the factors presumptive effect, subject to rebuttal.

HB15-1016 Rainwater Harvesting Pilot Project Regional Factors

2019

by

Ryan Gilliom

July 1, 2019, revised September 2019

COLORADO
Division of Water Resources
Department of Natural Resources

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APPENDIX

1 Introduction

This report documents enhancements to work completed by Leonard Rice Engineers (LRE) in support of the Dominion Water & Sanitation District Water Plan Grant titled "Regional Factor Development for Precipitation Harvesting."[1] The goal of this effort is to extend LRE's work investigating Historic Natural Depletion (HND)[2] on the Sterling Ranch pilot project[3] area to statewide HND Factors that can be applied at rainwater harvesting pilot projects across most of Colorado. The HND Factors are used to determine the allowable rainwater harvest depth while protecting senior water rights. To be available for use by pilot projects, the Factors must be approved for incorporation into the Colorado Water Conservation Board's (CWCB) Criteria and Guidelines for Rainwater Harvesting Pilot Projects.

According to the 2016 Criteria and Guidelines, all proposed HND Factors submitted to the Board for inclusion to the Criteria and Guidelines shall include, at a minimum:

- A map of the region where the Factors can be applied,
- A description of the data collected by the sponsor,
- A description of the methodology used to develop the proposed Factors,
- A description of the proposed Factors and any limitations of use,
- Draft updated Criteria and Guidelines that incorporate the proposed Factors.

This report contains the required information and is submitted in conjunction with draft updated Criteria and Guidelines for CWCB approval in September 2019.

2 Background and HND Factors Summary

2.1 Pilot Project and Factors Background

Rainwater harvesting pilot projects are a program established by the Colorado State Legislature to explore the potential of neighborhood-scale rainwater harvesting as a portion of a new development's renewable water supply. In a pilot project, stormwater runoff can be stored and distributed for outdoor use in new residential or mixed-use development. If approved for a pilot project, a development may reuse rainwater onsite through a Substitute Water Supply Plan (SWSP) and apply for a decreed augmentation plan specific to the development[4]. Per CWCB Criteria and Guidelines, the SWSP can use HND Factors, rather than site-specific information, to estimate allowable harvest volume at a pilot project site.

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[1] Dominion Water & Sanitation District Colorado Water Plan grant awarded 2017.
[2] Historic Natural Depletion and allowable harvest volume are used interchangeably throughout this report. They both represent the amount of water that can be captured and reused without injury to senior water rights.
[3] LRE Colorado Water Plan grant deliverables, Task 4.
[4] Refer to DWR Rainwater Harvesting Legal Framework Memo for additional information about the SWSP and Augmentation Plan processes.

The pilot project statute allows the storage and outdoor use of water that was historically consumed by natural vegetation and thus was not available to water users in the priority system. The HND Factors proposed in this memo estimate the HND for a pilot project, based on hydrologic soil group (HSG)[5] and on-site precipitation monitoring. HND Factors calculate a depth, which is multiplied by the land area made impervious by the development, as shown in Figure 2.1.

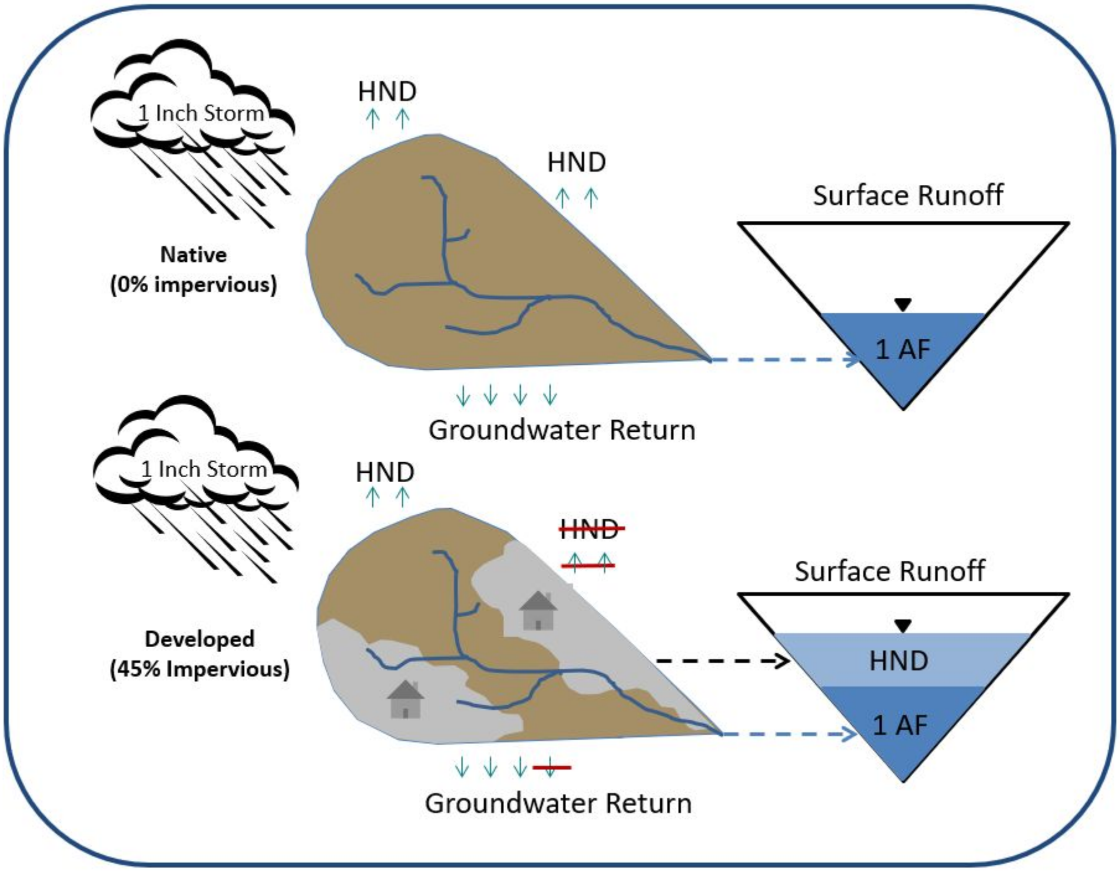

Figure 2.1: Comparison of runoff and Historic Natural Depletion (HND) in natural and developed catchments. HND occurs via evapotranspiration from soil moisture; increased impervious area decreases infiltration to the soil moisture storage.

2.2 HND Factors Summary

This memo proposes HND Factors based on three parts: Infiltration Factor, Groundwater Factor, and ET/Soil Factor. The three factors are applied together to estimate Daily HND and limit Monthly HND (Figure 2.2), which determines the amount of runoff that may be harvested on-site for pilot projects. The HND Factors are based on the concept that HND is equal to water that infiltrated to soil moisture storage, but did not become groundwater return flow, in other words, infiltration minus deep percolation. The Factors only apply to precipitation falling as rain during the growing season, in this case proposed as March through October.

[5] Soils are classified into four HSGs (A, B, C, and D) based on the soil's runoff potential. A's generally have the smallest runoff potential and Ds the greatest.

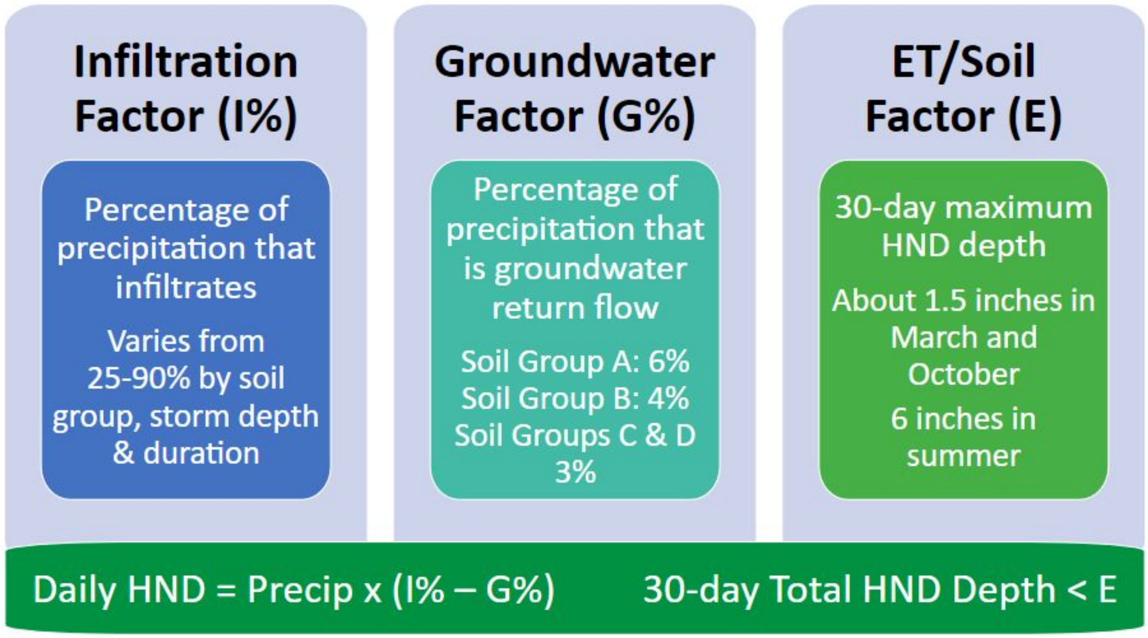

Figure 2.2. Summary of three-part HND Factor and HND calculation

The three parts of the HND Factor are:

1. Infiltration Factor (I%): the percentage of precipitation depth that infiltrated under natural conditions and was available for HND and groundwater return flow. For most storms, the Infiltration Factor is 90 percent of the precipitation depth, but for higher intensity storm events, the percentage decreases. The reduced infiltration percentage occurs more readily for finer soils, such as HSG A and B and less readily for coarser soils, HSG C and D. This memo defines different curves of the Infiltration Factor for each HSG. Figure 2.3 is an example of an Infiltration Factor curve.

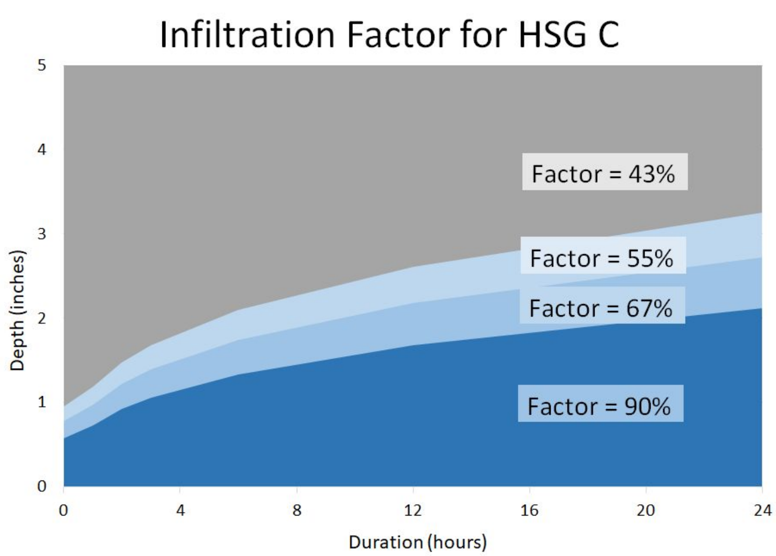

Figure 2.3: Example Infiltration Factor Curve

2. Groundwater Factor (G%): the percentage of precipitation event depth that infiltrated under natural conditions and then deep percolated past the root zone and is assumed to become groundwater return flow. This is a percentage of precipitation depth that varies by soil group as follows: HSG A = 6%, HSG B = 4%, HSG C = 3%, HSG D = 3%. The Daily HND is the portion of precipitation that infiltrated but did not continue past the root zone as deep percolation (Figure 2.2).

3. ET/Soil Factor (E): a maximum harvest rule applied as a 30-day running total limit on HND depth to account for natural processes that limit HND on a term longer than one day. These processes include back-to-back storms that reduce infiltration rates, soil moisture storage capacity that fills and cannot be depleted under wet conditions, and native vegetation ET rates that vary by season. The ET/Soil Factor 30-day limits on HND are much greater than average monthly precipitation in Colorado and would only limit rainwater harvesting under unusually wet conditions. The ET/Soil Factor 30-day limits are shown below.

Table 2.1: ET/Soil Factor 30-day HND Limit

	Mar	Apr	May	June	July	Aug	Sep	Oct
ET/Soil Factor (in)	1.4	3.9	5.4	6.0	6.0	5.8	4.0	1.5

The pilot project accounting template includes the calculations for all three parts of the HND. The user will set up the accounting template to include the area made impervious by development and the HSG proportions of the impervious areas. The template uses these parameters to calculate the Daily HND using 15-minute precipitation data from an on-site rain gage and provides the allowable harvest volume for that day at the pilot project site (Figure 2.4).

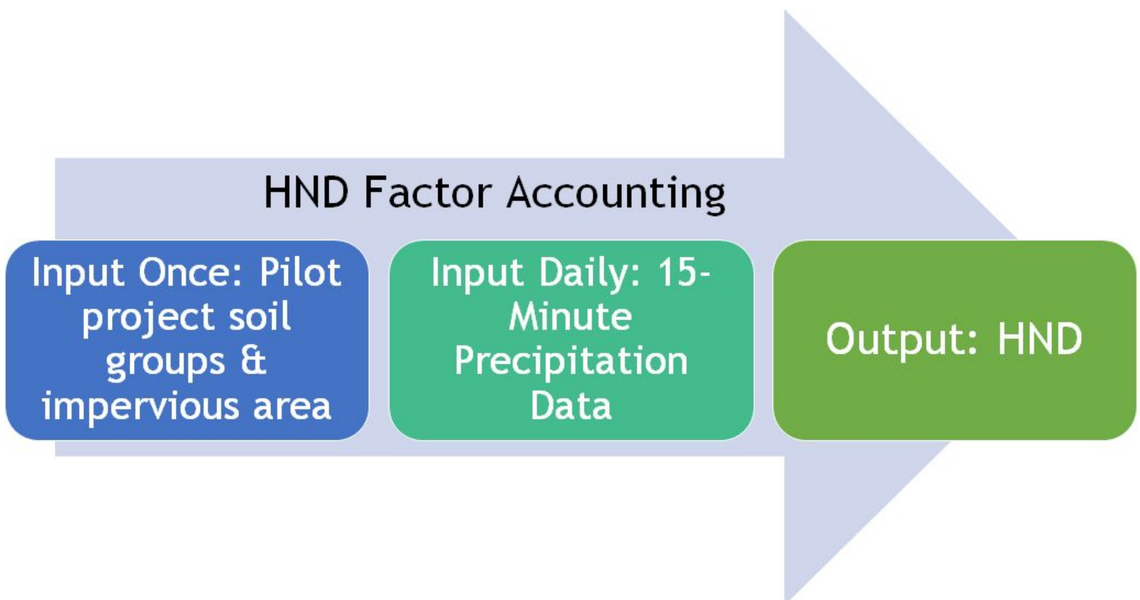

Figure 2.4: Summary of accounting procedure

2.3 Previous Work: Sterling Ranch Pilot Project

LRE's Colorado Water Plan Grant Task 4B developed Factors using data from Sterling Ranch, the only pilot project in operation. LRE found the average HND to be 95% of precipitation from 8 years of monitoring and modeling the Sterling Ranch catchment.[6] This is in accordance with other local observations such as a USGS study that found an annual mean of 83% HND in Jefferson County,[7] as well as hydrology literature for semi-arid regions, where modeled HND ratios vary from 74%-100% of precipitation.[8] LRE's Water Plan grant evaluated Factors applicable only to the HSG that occurs on Sterling Ranch (HSG C). LRE also developed a simplified approach to Factors based only on storm depth. This memo summarizes further analysis to develop Factors for all four HSGs based on considerations in addition to storm depth that impact HND. The analysis resulted in the conclusion that storm event intensity and duration can impact HND and can be reasonably incorporated in HND Factors.

2.4 Map and Limitations of Factors Application

The proposed Factors estimate HND for storm events on each HSG using precipitation depth and duration information combined with infiltration-runoff modeling. The runoff modeling was completed for precipitation falling as rain but did not consider snow. Thus, these Factors can be applied throughout most of Colorado, with three significant limitations: snowmelt may not be harvested, pilot projects cannot claim HND in absence of pre-development vegetation, and pilot projects cannot claim HND in areas of rock outcrop.

The map in Figure 2.5 generalizes the proposed areas of Colorado where the HND Factors can be applied in an SWSP. HND Factors can be applied in areas of Colorado with soil to support infiltration and vegetation. The NRCS Web Soil Survey should be used by applicants to show that appropriate soils exist in the catchment area. As shown in Figure 2.6, the Web Soil Survey provides spatial and tabular data for an area up to 100,000 acres, including HSG and soil descriptors. Rock outcrop is categorized as HSG D in the Web Soil Survey, with a soil descriptor field noting "rock outcrop". Any rock outcrop areas should be excluded from HND credit.

Natural depletion of snowmelt, and potential capture thereof, were not evaluated by either LRE for the Water Plan Grant nor this analysis. Therefore, precipitation that falls as snow and then melts to runoff should not be captured for reuse by a pilot project relying on the proposed Factors. The template accounting requires pilot project operators to exclude snow events from the precipitation record when determining daily HND for storage operations. A subsequent effort could propose the use of snowmelt in Factors. Or, a pilot project could propose a snow HND in a water court augmentation plan proposal to access snowmelt for harvest.

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[6] LRE Colorado Water Plan grant deliverables, Task 4A.
[7] Bossong et al., 2003. USGS WRI 03-4034.
[8] See Lesschen et. al (J. Geomorphology, 2009), Chauvin et. al (USDA-ARS, 2011).

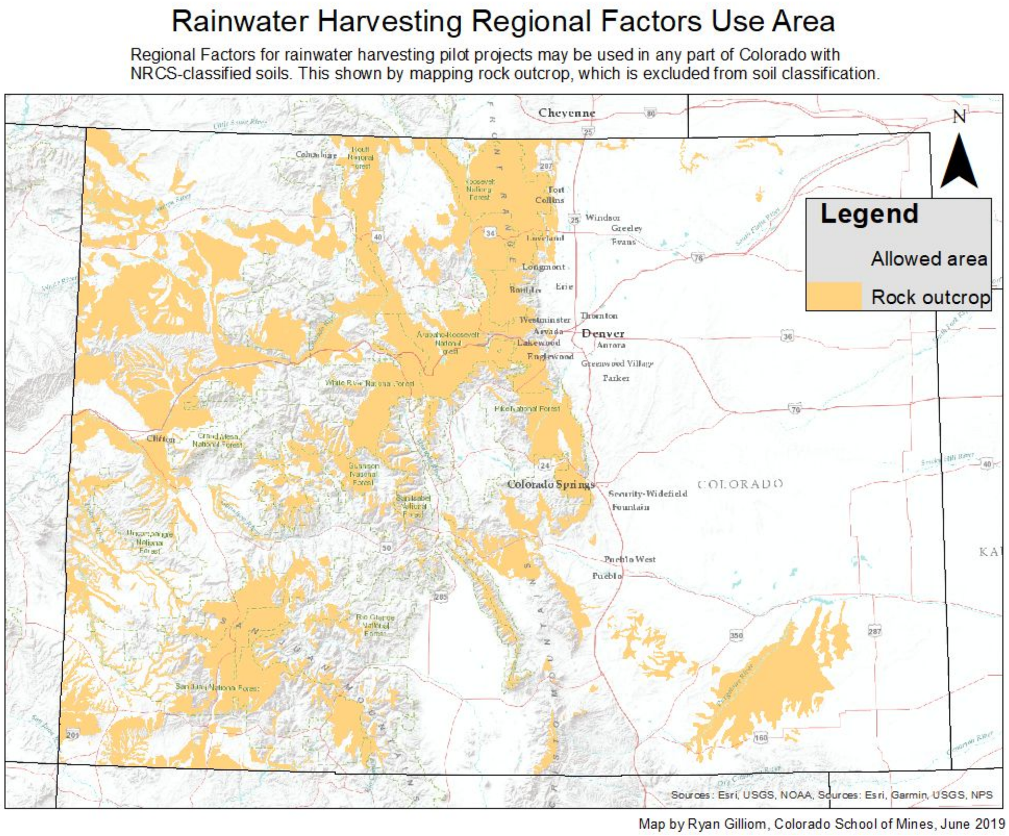

Figure 2.5: Map of areas eligible for proposed Factors.

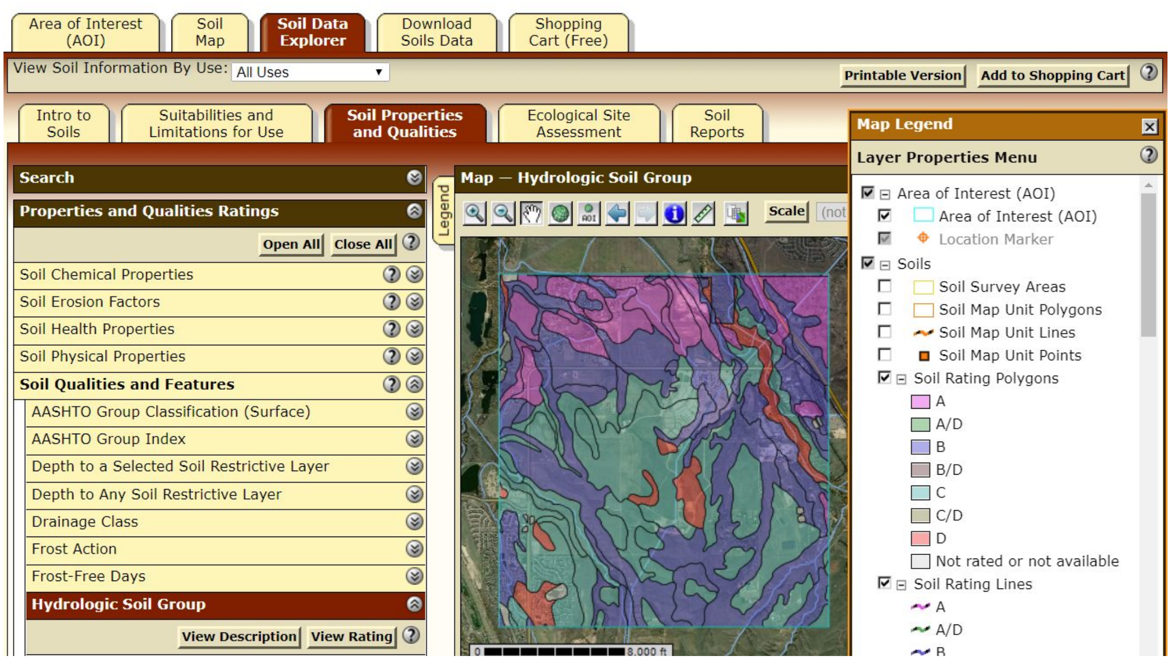

Figure 2.6: Web Soil Survey user interface and HSG map

3 HND Factors Development

The HND is defined as the portion of a rain event that, in natural pre-development conditions, was consumed by evapotranspiration and did not enter the stream system (Equation 1). To ensure a conservative estimate that protects senior water rights, the proposed HND Factors consider precipitation followed by infiltration and runoff independent of catchment size, slope, or vegetation, as further described below. Infiltration is presumed to portion into deep percolation below the root zone (which becomes groundwater return flow) and natural depletion (plant uptake and direct evaporation). All runoff is assumed to accrue to the stream. This approach excludes historic ET that may have occurred in transit between the location where the rain falls and the receiving stream (overland flow, ET from puddles and vegetation). HND is calculated as infiltration (Equation 2) minus groundwater return flows (shown in Equation 1; Groundwater Return is assumed to equal 3-6% of precipitation, depending on soil group). Finally, the volume of HND that may be harvested is calculated based on impervious area in the development (Equation 3).

$$Historic\ Natural\ Depletion = Precipitation \times (\%Infiltration - \%Groundwater\ Return)$$

(Equation 1)

$$\%\ Infiltration = \frac{Precipitation - Runoff}{Precipitation}$$

(Equation 2)

$$Allowable\ Harvest\ [acft] = HND[in] \times Area\ Made\ Impervious\ [acres] \div 12$$

(Equation 3)

3.1 Infiltration Factors Development

3.1.1 Infiltration Modeling

3.1.1.1 Modeling Methods and Site Slope

Following LRE's work, this analysis modeled the partitioning of precipitation into runoff and infiltration using WQ-COSM version 3.1, a rainfall-runoff model developed by Denver's Urban Watershed Research Institute. Post-processing of model outputs further partitions infiltration into deep percolation, which becomes groundwater return flow, and water that remains in the soil root zone, which becomes HND via evapotranspiration. The model was selected by LRE for the following reasons: the Hortonian infiltration method underestimates infiltration;[9] the model is continuous, allowing for the simulation of wet or dry antecedent conditions, and the exclusion of overland flow modeling excludes infiltration in transit from the HND estimate, a conservative approach.

Land slope is not considered in the WQ-COSM model, but the impact of land slope on infiltration was researched for possible inclusion in HND Factors. Although high slope angle can affect infiltration-runoff partitioning due to reduced depression storage and

[9] Green, I.R.A. An explicit solution of the modified Horton equation. J. Hydrol. 1986.

infiltration rate,[10] experimental data from arid and semi-arid sites showed that slope angle does not considerably impact infiltration-runoff partitioning.[11]

Higher slope angles may decrease a site's capacity for depression storage, which can increase infiltration potential of initial runoff. Since the infiltration modeling using WQ-COSM excludes losses that may occur during runoff transport, the impact of slope on depression storage is not appropriate to consider for the HND Factors. Further data from arid and semi-arid sites found that runoff (and inversely natural depletion, per our assumptions) is most strongly related to total precipitation and precipitation intensity, which are accounted for in the Factors.[12]

3.1.1.2 Modeling Data

Data to develop statewide Factors were generalized to the highest level possible. Soil infiltration parameters for the model are based on the recommended values for the Natural Resources Conservation Service'sHSGs.[13] HSG are mapped in a geospatial database and can be referenced for a pilot project anywhere in the state.[14] Precipitation events were constructed using Front Range depth-duration storms for 1, 2, 5, 10, and 25-year return intervals with durations of .25, .5, 1, 2, 6, and 24 hours.[15] Smaller storms were simulated by using a fraction of the 1-year event depth (.25, .5, and .75); these are not true return interval events, but adequately represent smaller more frequent storm depths. The modeled events range in depth from 0.13-3.63 inches and in intensity from 0.04-4.00 inches/hour. While event depth for each duration and return interval will vary across the state, the range of depths used here will appropriately represent possible precipitation events across Colorado.

Distribution of precipitation within an event can vary, which can impact infiltration estimates. The difference between precipitation patterns in western and eastern Colorado was evaluated using regional distributions of intensity from the Colorado Regional Extreme Precipitation Study.[16] There was not a meaningful difference in infiltration between these precipitation regions, as further discussed in Appendix A.

3.1.1.3 Modeling Assumptions

Throughout Factor development, conservative assumptions were made such that the outcome would minimize the infiltration estimate (Equation 2). The Horton infiltration model projects a constant decay in infiltration rate over time, while infiltration rate

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[10] Ebrahimian et al. 2012, Polish J. of Env. Studies; Mishra et al. 2014, Water Res. Mgmt.
[11] Yair and Raz-Yassif 2004, Geomorphology.
[12] Ries et al. 2017, J. Hydrology: Regional Studies.
[13] National Engineering Handbook Ch. 7: Hydrologic Soil Groups. USDA NRCS, 2007.
[14] USDA NRCS Web Soil Survey tool can be used to download soils mapping for an area up to 100,000 acres.
[15] Precipitation frequency depths were pulled from NOAA Atlas 14 for the Kassler Station near Sterling Ranch (ID 05-4452)
[16] CO-NM Regional Extreme Precipitation Study, Colorado Division of Water Resources Dam Safety, 2018.

actually decreases with infiltration and saturation in the field. Thus, in any rain event without constant precipitation, Horton provides a conservative infiltration estimate.[17]

Although these runoff modeling results are not validated with observed data, these minimizing assumptions give us confidence that the Factors are appropriately conservative for pilot project SWSPs. The Board may decide to apply an additional “safety factor” to the Factors in the Criteria and Guidelines if they deem it necessary.

3.1.1.4 Infiltration Sensitivity Analysis

As part of the modeling process, we conducted an analysis of modeled infiltration response to WQ-COSM parameters and precipitation input characteristics. The following parameters were evaluated to determine if changing their values within the model’s recommended range would have a significant impact on infiltration: initial and final infiltration rates, infiltration decay rate, pervious depression storage, storm separation, minimum depth to runoff, and drying period (time to full infiltration rate recovery).This analysis is detailed in Appendix A of this memo. Findings were used to inform final model parameter values as well as accounting rules. HSG infiltration parameters are reported in Table 3.1; other model parameters are detailed in Table 3.1 of Appendix A.

Table 3.1: HSG Model Parameter Values[18]

Soil Group	Initial Infiltration Rate (in/hr)	Final Infiltration Rate (in/hr)	Infiltration Decay Rate (-/hr)
HSG A	1.7	1.5	2
HSG B	1.4	1.2	3
HSG C	1.0	0.2	3
HSG D	0.3	0.1	3

3.1.2 Infiltration Factors

The Infiltration Factors are based on precipitation depth and duration as well as HSG. If Factors were based solely on precipitation depth, the impact of intensity would be lost, resulting in over- and under-estimation of HND. This complexity is included in a template accounting sheet to be used by pilot projects. Infiltration Factor accounting rules require high-resolution precipitation data monitored at the pilot project site (15-minute timestep), which is processed into storm events using a 3-hour dry period to define storm separation. The rules are applied separately for HSG, requiring acreage of

[17] For example, if a 6-hour event has rain only in the first 2 hours and last 2 hours, actual infiltration would reflect the dry 2-hour period in the middle. A Hortonian model of this event projects constant decline in infiltration rate over the 6 hours, independent of precipitation and cumulative infiltration. This results in a lower total infiltration.

[18] These parameter values are the lowest infiltration rate and fastest decay rate recommended for each soil group in the WQ-COSM manual.

area made impervious over each group. Some soils are classified as A/D, B/D, or C/D to indicate different infiltration capacity in different soil drainage conditions (water table more or less than 24 inches below surface).[19] For pilot project accounting purposes these combination soils should be classified as the well-drained HSG (A, B, or C) if the project sponsor can demonstrate that the water table is deeper than 24 inches.

3.1.2.1 HSG A

This sandy soil group has higher initial and final infiltration rates relative to typical precipitation intensity, resulting in a higher total infiltration capacity. The Infiltration Factor falls at 90% all but the most intense short events, where the ratio falls to 70% for events larger than 10-year (Figure 3.1). HSG A shows decreased infiltration when high-intensity events deliver precipitation at a rate that exceeds infiltration rate. The infiltration rate decays from initial to final in approximately 5 minutes, but HSG A has a final modeled infiltration rate that is higher than typical rain intensity, thereby allowing most of the rainfall to infiltrate for longer duration events. With only the most intense rain events diverging from 90%, a simple two-part rule is recommended (Figure 3.2).

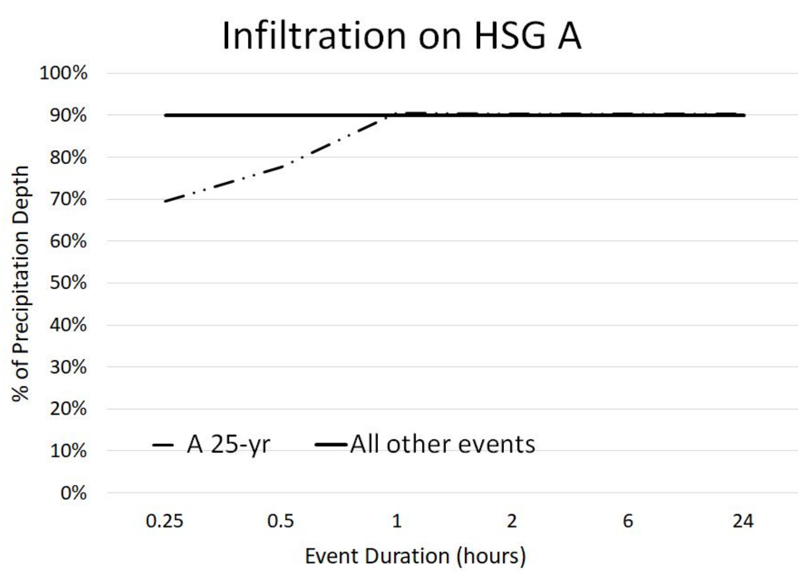

Figure 3.1: Infiltration modeling results for HSG A

[19] National Engineering Handbook Ch. 7: Hydrologic Soil Groups. USDA NRCS, 2007

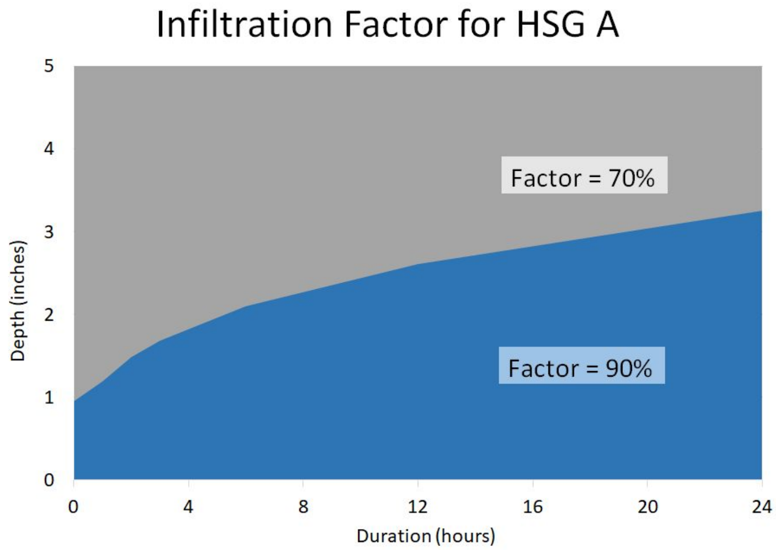

Figure 3.2: Infiltration Factor for HSG A. Events smaller than the 10-year event use I%=90%, while larger events use 70%.

3.1.2.2 HSG B

The sandy HSG B soils have higher initial and final infiltration rates similar to HSG A. On these soils, low-to-moderate intensity rain events have a 90% or greater infiltration/precipitation ratio, while short infrequent events of high-intensity diverge and the ratio falls to 62%-80% infiltration/precipitation for HSG B (Figure 3.3). Like HSG A, HSG B shows decreased HND when high-intensity events deliver precipitation at a rate that exceeds infiltration rate. The infiltration rate decays from initial to final in approximately 5 minutes, but HSG B has a final modeled infiltration rate that is higher than typical rain intensity, thereby allowing most of the precipitation to infiltrate. The recommendation for HSG B is a three-part rule (Figure 3.4).

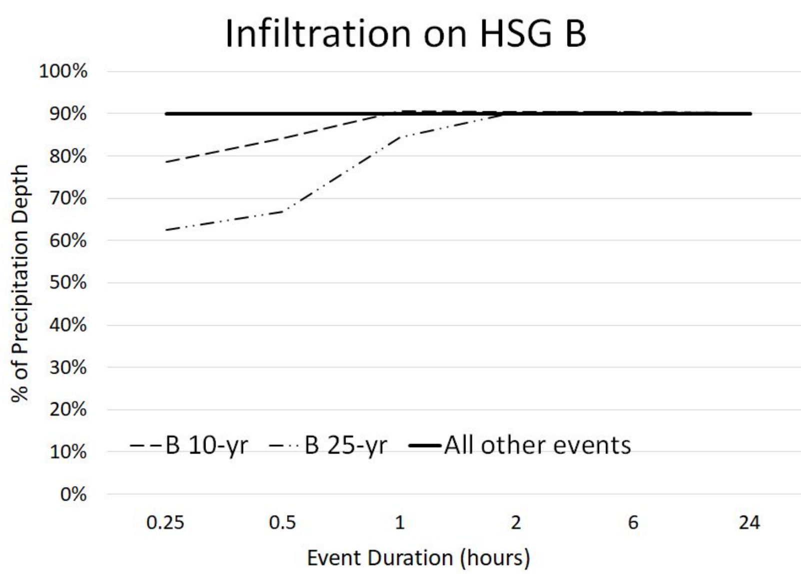

Figure 3.3: Infiltration modeling results for HSG B

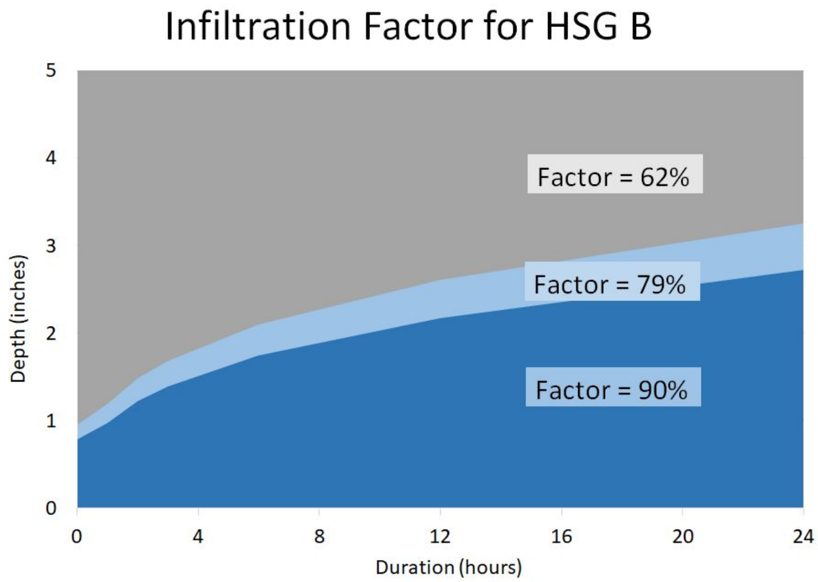

Figure 3.4: Infiltration Factor for HSG B. Events up to the 5-year use %I=90%; those greater than the 10-year event use 62%, with intermediate events using 79%.

3.1.2.3 HSG C

The more loamy and clay-dominant HSG C has an initial infiltration rate close to HSG B's final rate and a very low final infiltration rate. The infiltration/precipitation ratio on HSG C follows the 90% ratio up to the 5-year event, breaking at a lower intensity than HSGs A and B (Figure 3.5). A different pattern is observed with HSG C than A and B; on HSG C, the shortest and longest intense events have higher infiltration than mid-range event duration of 1-6 hours. Because the infiltration rate decays to the final value in 16 minutes, 15- and 30-minute events have a bulk of their precipitation falling on higher infiltration rates. Meanwhile, most precipitation in longer events falls on the lower final infiltration rate. The effect of this low final infiltration rate is most significant on mid-range events; longer events allow a higher proportion of the event to infiltrate, as even high-volume events are low-intensity over a long duration. The rule recommendation for HSG C includes more individual factors to accommodate the higher variation in infiltration estimates (Figure 3.6).

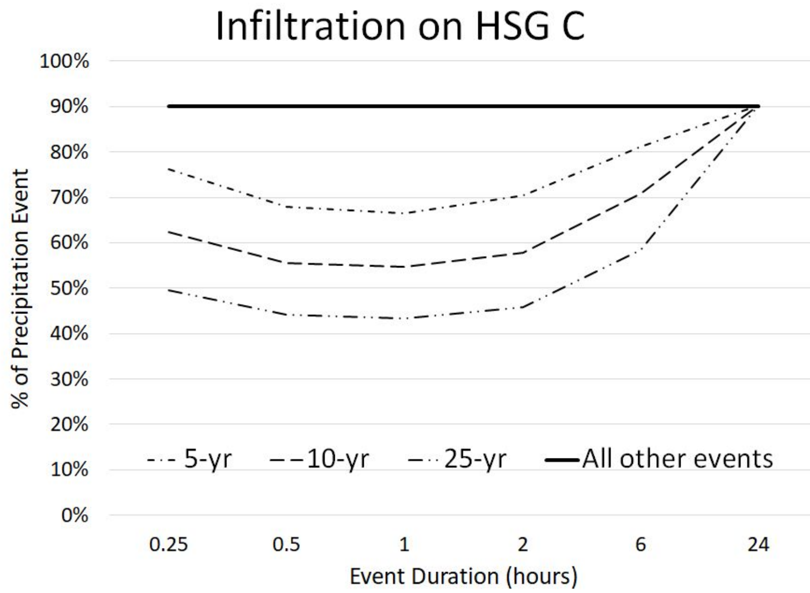

Figure 3.5: Infiltration modeling results for HSG C

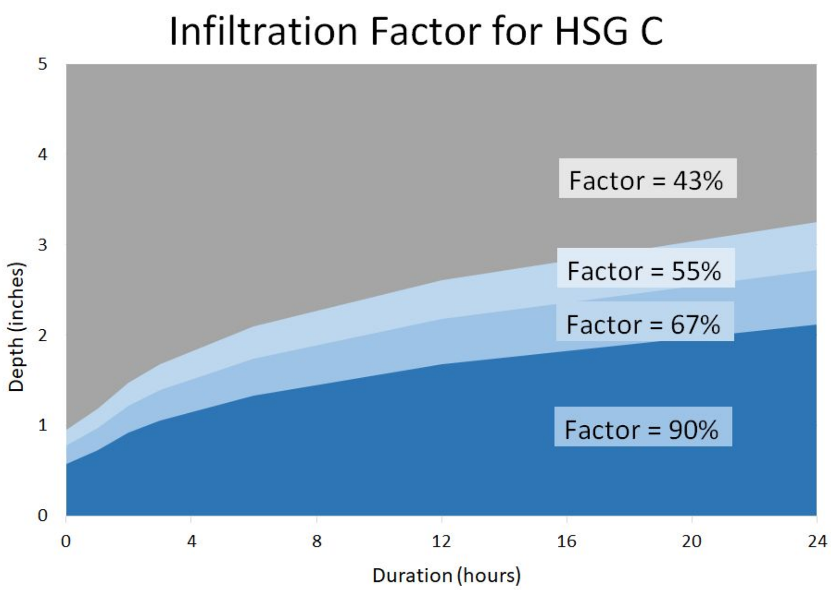

Figure 3.6: Infiltration Factor for HSG C. Events up to the 2-year use %I=90%; those greater than the 10-year event use 43%, with intermediate factors divided by the 5-year event.

Figure 3.7 shows the estimated HND depth from the LRE factors (based only on total storm depth),[20] compared to the variety of Factors that could occur when storm intensity is considered based on the Infiltration Factor recommended in this report. These results are for HSG C, the dominant soil type at Sterling Ranch and the soil group for which LRE developed an Infiltration Factor recommendation. For all but the smallest events, the Infiltration Factor proposed in this memo allow a higher harvest

[20] LRE Colorado Water Plan Grant deliverables, 2019.

volume than the depth-only findings by LRE, which were set to be conservative based only on a storm depth consideration. The HSG C Infiltration Factor recommended in this memo breaks down to three sections: 90% for lower intensity events and some small intense events (less than 0.5 inches), 55% for short high-intensity and long low-intensity events, and 40% for longer high-intensity events.

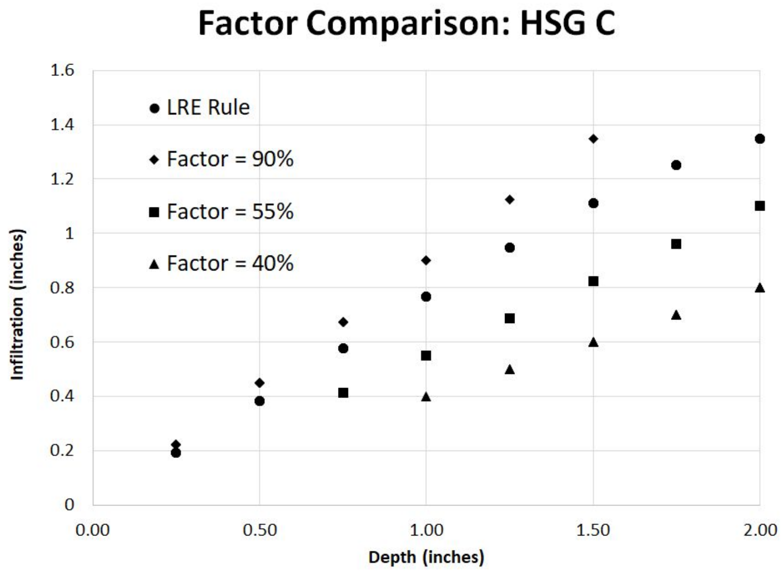

Figure 3.7: Comparison of infiltration estimates as determined by the LRE Water Plan Grant and the proposed Factors in this memo where Factors for each depth vary by intensity as a result of different event durations.

3.1.2.4 HSG D

This HSG is essentially clay, with very low initial and final infiltration rates. Initial infiltration is so low that time to the final rate is nearly irrelevant. As shown in Figure 3.8, only smaller storms with less than a 1-year return interval meet the 90% ratio of infiltration/precipitation. However, these are common, frequent storms, so a pilot project located on HSG D would be able to harvest 90% of precipitation for the majority of events. The rule recommendation for HSG D includes more individual factors to accommodate the higher variation in infiltration estimates (Figure 3.9).

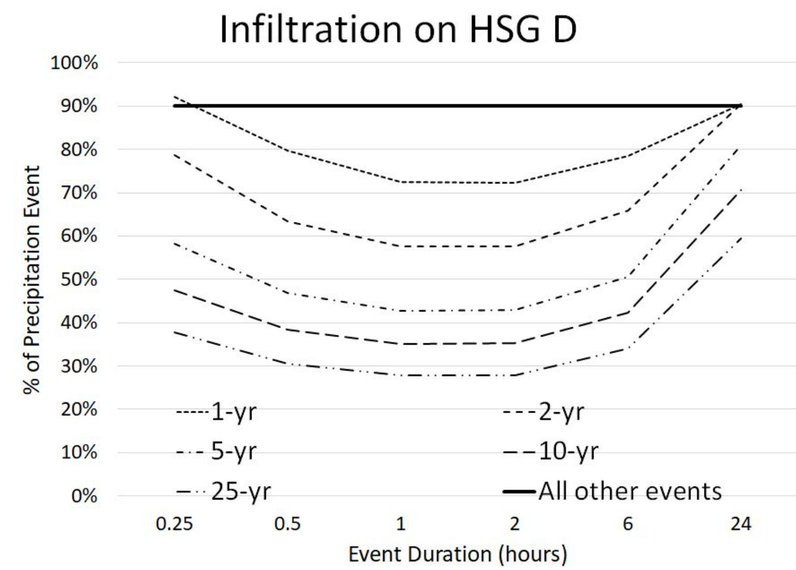

Figure 3.8: Infiltration modeling results for HSG D

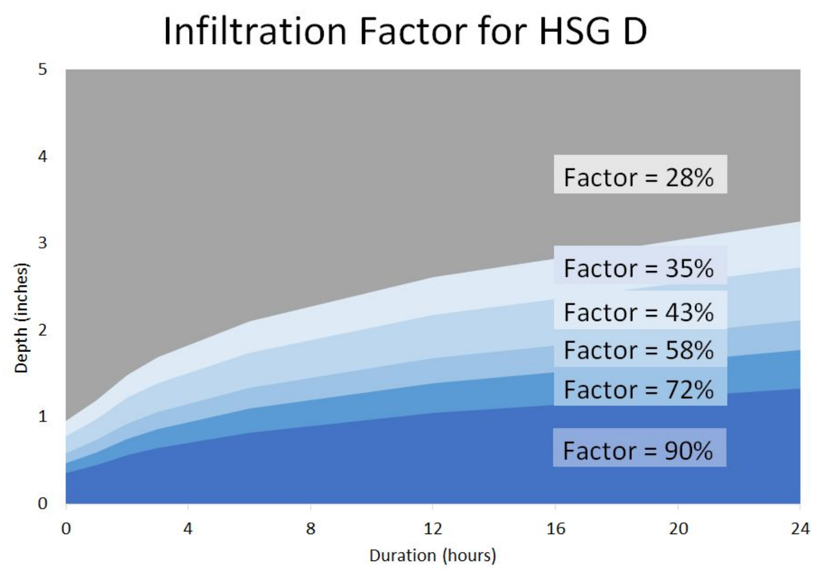

Figure 3.9: Infiltration Factor for HSG D. Events up to the 0.75-year use %I=90%; those greater than the 10-year event use 28%, with intermediate factors divided by the 1-, 2-, and 5-year events.

3.2 Groundwater Factors

3.2.1 Groundwater Factors Development

Groundwater return flows are a part of the infiltrated precipitation modeled in WQ-COSM. Therefore, the Infiltration Factor estimates both groundwater return flow to the stream and infiltrated water retained in soil moisture storage within the root zone for consumption by vegetation (HND). This analysis did not include a separate water budget accounting for infiltrated water, but bases the Groundwater Factor recommendation on (1) results summarized by LRE in their Task 4C grant memo, which include findings on Sterling Ranch and assumed deep percolation rates for several state-accepted models Colorado, and (2) other resources on deep percolation and soil type.

3.2.1.1 Sterling Ranch Observation and Simulation

As described in LRE's Task 4C memo, instruments were monitored at a weather station on Sterling Ranch in a small undeveloped natural catchment within the pilot project area. The installation included a 3.75 foot deep lysimeter, which monitored infiltration and deep percolation from April 2014 through July 2018. Over these 5 growing seasons, 0%-3% of the precipitation was observed percolating past the root zone in the locations HSG C soil. LRE also simulated runoff, soil moisture storage, evapotranspiration (using Penman-Monteith), and deep percolation at Sterling Ranch using the 1-dimensional Hydrus 1-D model calibrated to lysimeter observations. Over the model simulation period of April, 2010 through May, 2018, deep percolation totaled 2% of the observed precipitation. In a separate soil moisture model, LRE simulated deep percolation at the Sterling Ranch lysimeter using a daily soil reservoir accounting model and different infiltration estimates. The results of this effort, no matter what method was used to estimate infiltration, also simulated that 2% of total precipitation deep percolated between 2010 and 2018. Together these observational and model findings led to LRE's recommendation of 3% groundwater return.

In LRE's observations and simulations they note that deep percolation was rare, occurring only when soil moisture storage was exceeded.[21] Deep percolation was observed and simulated to occur after back-to-back large storms where there was not time for soil moisture storage to be depleted by evaporation and transpiration. With soil moisture remaining nearly full, a new precipitation event would cause infiltrated water to exceed soil moisture storage, resulting in deep percolation.

3.2.1.2 Deep Percolation in Colorado Models and Literature

LRE summarized that the South Platte and Arkansas River Decision Support System models both assume that deep percolation is 3% of precipitation on undeveloped pervious surface. In these two models, deep percolation does not vary with soil type. LRE further summarized the more complex approach for the Republican River Compact Administration Model, which uses deep percolation curves that increase with annual precipitation and that simulate higher recharge for coarser soils. A summary of the native soils recharge percentages is shown in the chart below (Figure 3.10). Model documentation states that the deep percolation assumptions in the model are based on a "compromise agreement,"[22] suggesting that the rates are not solely based on scientific understanding. However, scientific literature confirms the assumption that coarse-grained or sandy soils generally result in higher recharge rates than do fine-grained loam and clay soils.[23,24]

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[21] Only two years out of the 8-year record resulted in modeled deep percolation (2015 and 2017). LRE Colorado Water Plan Grant deliverables, 2019.

[22] Republican River Compact Administration Model, June 2003 (no author listed).

[23] Scanlon, B.R., et. al., 2002. "Choosing appropriate techniques for quantifying groundwater recharge." Hydrogeology Journal.

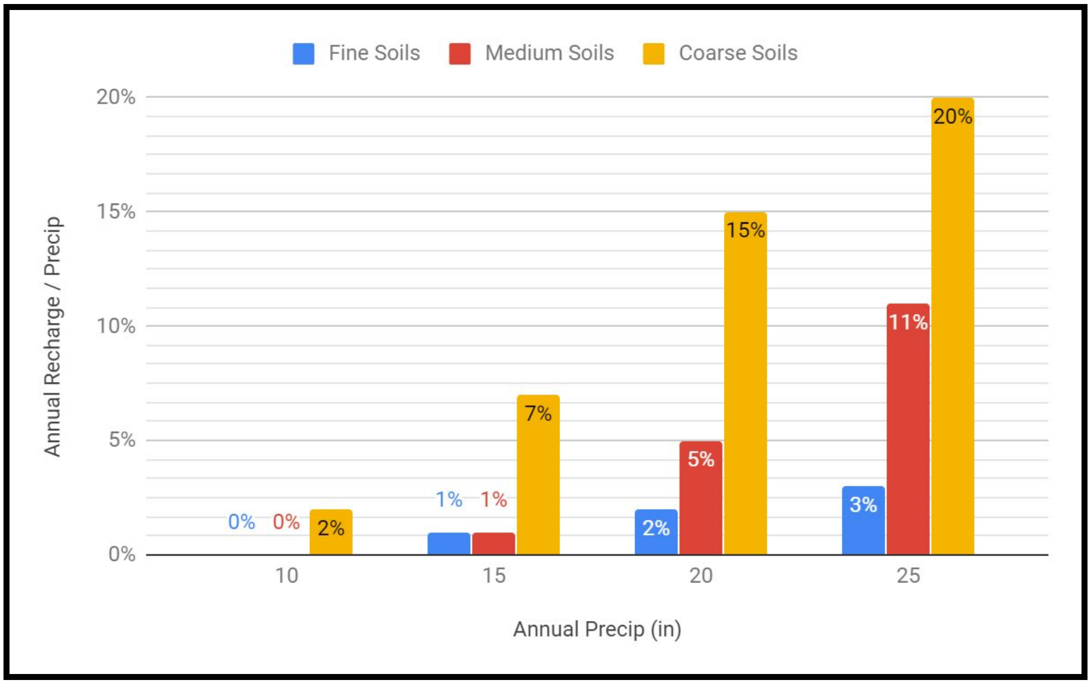

Figure 3.10. Republican River Compact Administration Model groundwater percentages

3.2.2 Groundwater Factors

This report recommends that groundwater return flows are accounted as a constant percentage of precipitation, varying by soil group. For the finer soils, HSGs C and D, a 3% groundwater-precipitation ratio (G%) is recommended. For the coarser soils HSGs A and B, groundwater-precipitation ratios (G%) of 4% and 6%, respectively, are recommended.

3.2.2.1 Groundwater Return Flow Timing

Pilot projects have two options for groundwater return flow replacement. The first is to return the Groundwater Factor volume to the stream system at a constant rate based on the last 5 year average rainfall totals. The second option is to return the Groundwater Factor volume of each rain event through onsite recharge. The constant rate return flow obligation is about 5 acre-feet per year for a 160-acre impervious area and 12 inches of annual precipitation, on HSG C or D (G% = 3%), a flow rate obligation less than 0.01 cfs.

LRE's Task 4D Report describes how deep percolation at a location very near the stream or located in areas with highly transmissive soils could result in spikes of groundwater return flows to the stream system after large storms. The Groundwater Factor allows for constant return flow replacement due to the following considerations:

[24] Bethune et al., 2008. "Understanding and predicting deep percolation under surface irrigation." Water Resources Research.

- Groundwater return flow from precipitation events is a small volume of water, 5 acre-feet per year for the example above.

- Many pilot projects, such as Sterling Ranch, will be located in areas where travel through the aquifer to the stream attenuates fluctuation in groundwater return flow amounts.

- When new developments create impervious surfaces this reduces infiltration and reduces groundwater return flow from precipitation, changing the historical pattern of groundwater return flow. When this happens in a new development that is not harvesting rainwater, there is not a legal requirement to maintain historical stream conditions for senior water rights. Requiring a constant groundwater return flow for the proposed Factors is conservative compared to a development that creates impervious surfaces with no consideration of groundwater return flows.

3.3 ET/Soil Factor

Under certain conditions, modeled infiltration from storm events can exceed 10 inches in a short period. In most locations, 10 inches of water cannot be stored in the soil root zone and would deep percolate and could not be consumed by vegetation. A more reasonable amount of soil moisture storage within the root zone of Colorado's native plants is 6 inches.[25] Under natural conditions, soil moisture storage can be filled by precipitation and then is reduced by native plant ET at a rate that is directly related to temperature and other weather conditions, reducing the amount of water in storage until the next rain event adds more water to soil moisture storage. In typical historical consumptive use calculations a soil moisture water balance performed on either a daily or monthly time-step is used to determine how the soil moisture storage changes over time. A temporal water balance is too complex to include as part of the Factors. A simplified alternative for the Factors is a 30-day running limit on HND to account for physical limits on HND during wet periods. The limit is based on ET rates and soil moisture storage as described below.

Figure 3.11 shows average monthly meadow grass ET in four populated areas of Colorado, which are potentially representative of pilot project locations. Average monthly meadow grass ET ranges from 1.5 inches in the early and late season to about 7-8 inches in June and July.[26,27] Although water may infiltrate at a rate greater than ET, HND cannot exceed the rate at which plants consume water.

[25] Using the same assumption required for pilot projects pursuant to Criteria and Guidelines for Fallowing-Leasing Pilot Projects, 2016.
[26] Thompson, K.L. 2019. Evaporation and Evapotranspiration Estimates for Colorado (Draft). Under review by I.A. Walter, T.W. Ley, and Wilson Water Group. Technical Memorandum, Colorado Division of Water Resources, Denver CO.
[27] ASCE Standardized ET Equation with Manual 70 perennial ryegrass crop coefficients. ASCE Manual 70. 2016. Evaporation, Evapotranspiration, and Irrigation Water Requirements. Second Edition. Eds. Marvin E. Jensen and Richard G. Allen; Environmental and Water Resources Institute of the American Society of Civil Engineers.

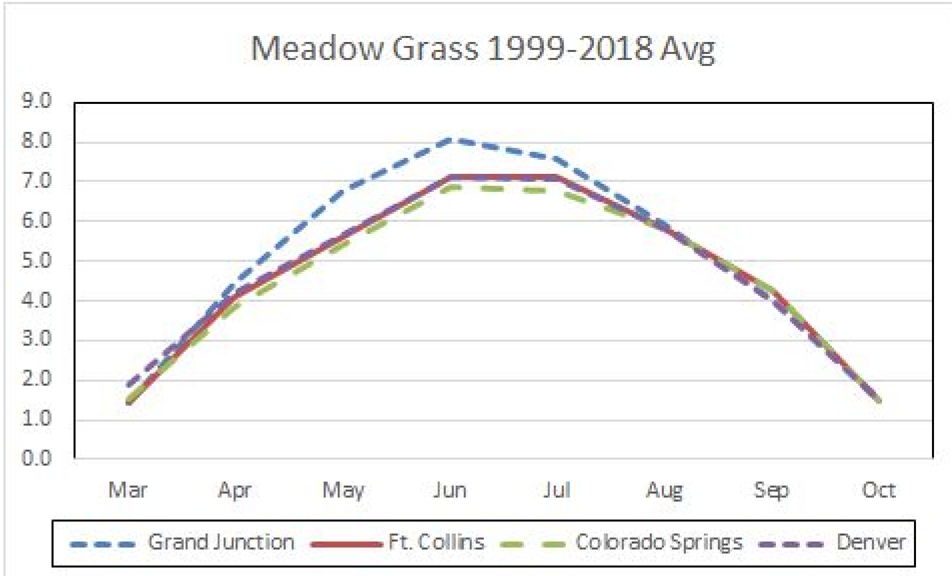

Figure 3.11: Monthly Meadow Grass ET in Colorado developed areas

In June and July, when plant ET is greatest, during a wet period, HND could potentially be limited by soil moisture storage of 6 inches rather than plant ET. Figure 3.12 shows the minimum monthly ET from the four locations in Figure 3.11 with a 6 inch limit applied in June and July as the ET/Soil Factor. The average monthly precipitation in Denver totals 13 inches between March and October with a maximum monthly total of 2.3 inches in May. Under "average" precipitation conditions, the ET/Soil Factor will not limit rainwater harvesting.

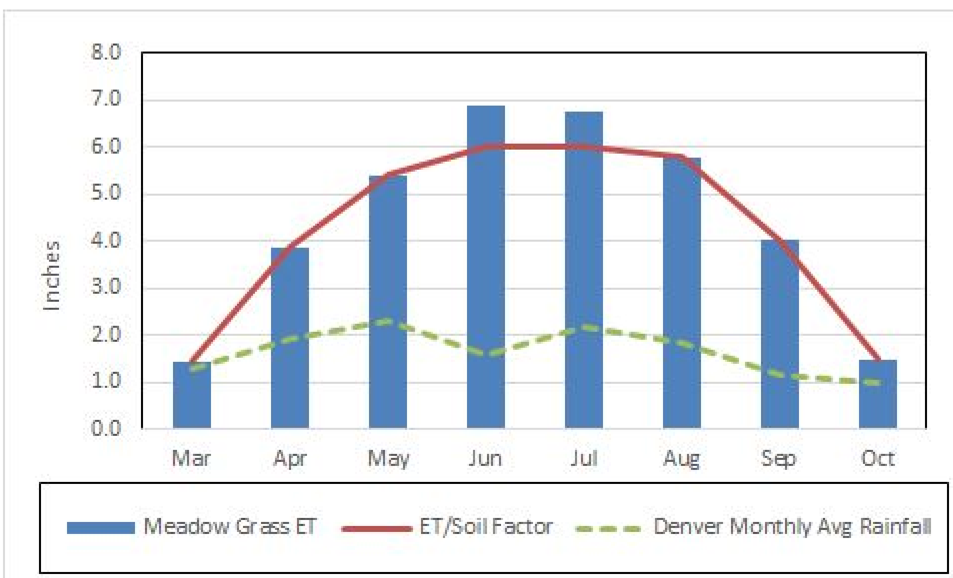

Figure 3.12: ET/Soil Factor compared to Meadow Grass ET and average precipitation

4 Comparison of Factors with Effective Precipitation Methods

HND is similar to the concept of effective precipitation, the amount of precipitation that is consumed by irrigated crops. Different effective precipitation methods are used in water accounting tools in the State of Colorado. This section compares the proposed HND Factor with two effective precipitation methods, Soil Conservation Service (SCS) and the Bureau of Reclamation, to provide a comparison with the HND Factors.

The SCS method of estimating monthly effective precipitation considers usable soil water storage, monthly precipitation, and monthly crop evapotranspiration.[28] Entering this data for Denver results in a monthly amount of precipitation that may be consumed by irrigated crops. As shown in Figure 4.1, the SCS effective precipitation method estimates that on average between 68% - 91% of precipitation is consumed by crops, with a greater percentage of the consumption occurring in the summer months. These percentages are within the realm of the results of the HND Factors for consumption of precipitation by native vegetation. The documentation of the SCS method describes that there are two important factors that affect how much precipitation is consumed by crops: infiltration rate and rainfall intensity. Both of these considerations are part of the proposed HND Factors.

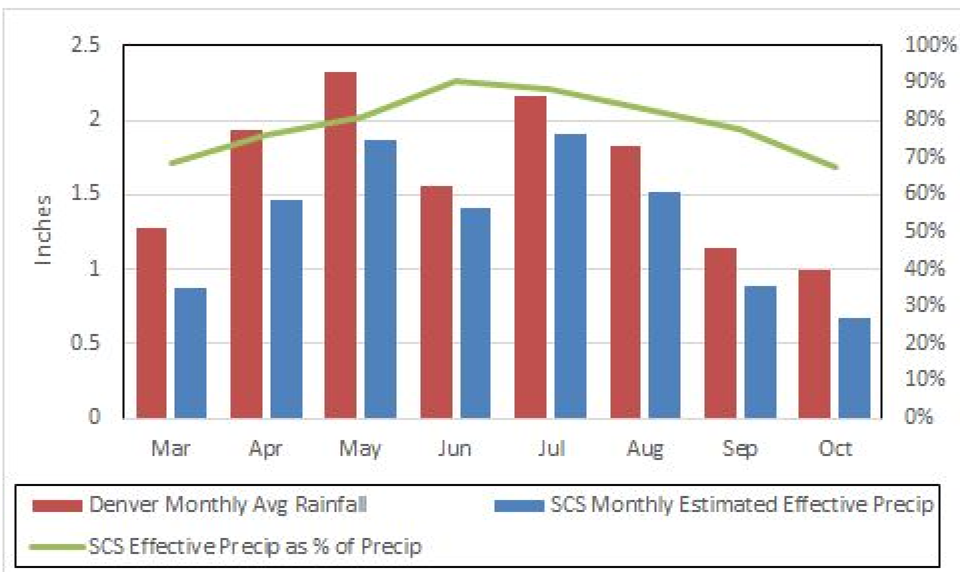

Figure 4.1: Comparison of average rainfall and SCS Effective Precipitation for Meadow Grass for Denver, assuming 6 inches of soil water storage.

As described in Colorado's StateCU model documentation (2008), Bureau of Reclamation's effective precipitation estimation is based only on monthly precipitation totals, where the first inch of precipitation is 95% consumed by plants, the second inch is 90% consumed, and less percent consumption with each subsequent inch of rainfall. Figure 4.2 shows how the percentage of rainfall that becomes effective precipitation decreases as monthly precipitation increases. This approach can be related to the

[28] National Engineering Handbook Part 623. United States Department of Agriculture, Soil Conservation Service. 1993.

proposed Factors in that with greater precipitation depth, a smaller percentage of the water is available for plant consumption. Furthermore, after six inches of precipitation in a month, very little additional precipitation contributes to Bureau of Reclamation's effective precipitation estimate, similar to the 6 inch limit established in the ET/Soil Factor.

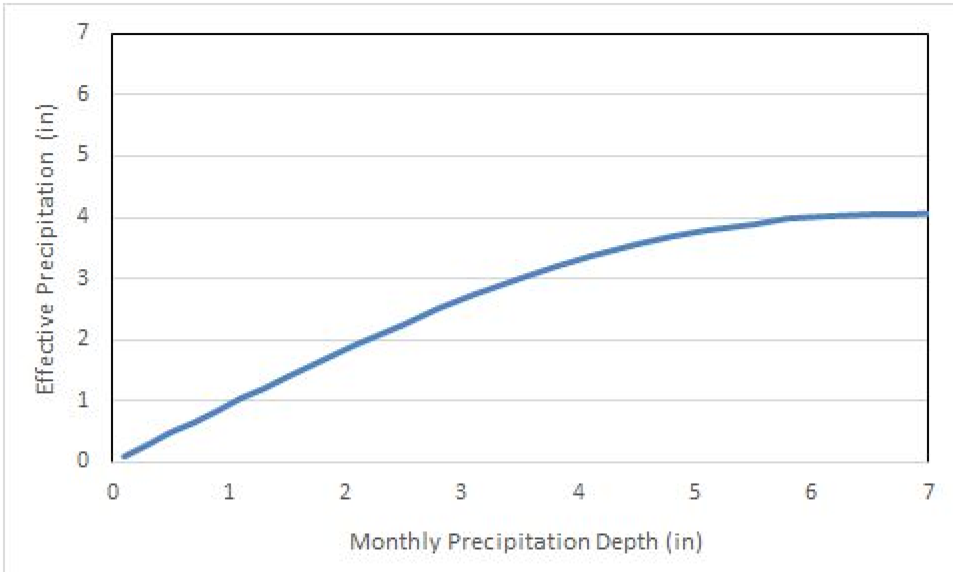

Figure 4.2: Bureau of Reclamation Effective Precipitation varies with monthly precipitation depth.

5 *Accounting Procedure*

Due to HND Factor complexity necessary to incorporate the impact of precipitation intensity, the HND Factor rules are programmed into an Excel accounting template. This will ease integration with pilot project daily accounting, which is required for all SWSPs. Daily allowable harvest volume is determined using on-site 15-minute observed precipitation, which the tool separates into storm events.[29] As shown in the accounting rule figures in Section 3, the Infiltration Factor is based on total storm depth and storm duration for that particular storm. The Excel accounting tool uses power trendlines fit to the depth-duration curve of Factor thresholds, allowing the tool to automatically determine which Infiltration Factor plot a given event should use. The ET/Soil Factor and Groundwater Factor are also included in the accounting template. Operators need to enter precipitation data daily as well as logging actual storage to track total harvest relative to the ET/Soil Factor limit. Any stored water in excess of the HND must either be released or augmented.

[29] Precipitation data will be processed using 3-hr storm separation period.

6 Example Application of Proposed Factors

6.1 Applying the Factors to an Event

Consider a storm event of 1 inch over 8 hours on HSG C. As shown in Figure 3.6 and Figure 2.2, respectively, the Factors for this event are I% = 90% and G% = 3%. This means that 90 percent of the rainfall would have infiltrated in native conditions and 3 percent would have deep percolated to become groundwater return flow, so that 87 percent would have been consumed. In a development with 45 acres impervious area, the allowable harvest is calculated as:

HND (in) = Precipitation x (I% - G%)

Harvest Volume (acft) = HND x (Area made impervious) ÷ 12 in/ft

Thus, for 45 acres of impervious surface, we find the allowable harvest volume as:

HND = 1.0 in x (90%-3%) = 0.87 in

Harvest Volume = 0.87 in x 45 acres ÷ 12 in/ft = 3.26 acft

From this event, a total of 3.26 acre-feet can be harvested for outdoor use at the pilot project site without augmentation.

Most precipitation events result in I% = 90% on HSG C, as in this example; in the 8-year precipitation record at Sterling Ranch, 290 of 297 observed events fall within the band where I% = 90% (Figure 6.1). The rules for HSGs A and B will allow even more events to use 90%, while HSG D will have a lower percentage of events where 90% of precipitation infiltrated under natural conditions.

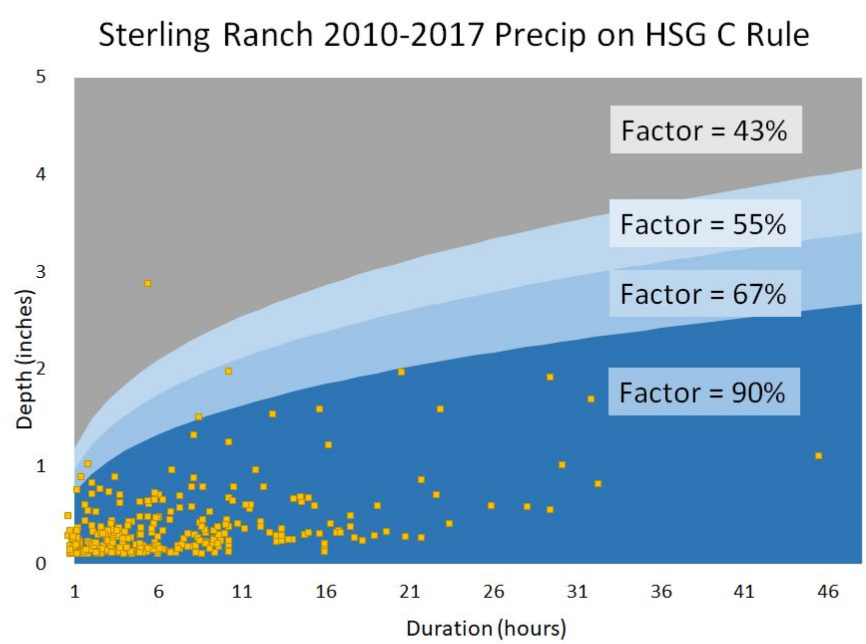

Figure 6.1: 2010-2017 Sterling Ranch precipitation record plotted on HSG C Rule

6.2 Meeting Outdoor Demand with Rainwater Harvesting

For context of supply and demand, we compare observed precipitation events in the Sterling Ranch record for the years 2010-2017 in the months March-October to a water demand estimate. For HSG C, annual HND with this precipitation ranges from 0.61-2.19 inches. In the same example development as above (45 acres impervious, HSG C), these depths convert to a monthly harvest volume of 2.28-8.20 acft. The median annual total harvest volume operating March-October is 42 acft, based on 2010-2017 precipitation observed at Sterling Ranch (see Table 6.1).

In an average Front Range residence, household water use is 0.4-0.5 acft with 55% use outdoors.[30] This equates to 0.22-0.25 acft of annual outdoor demand in an average home.[31] Assuming there are 400 homes in the example 100-acre development (45 acres of which are impervious surface), this results in 88-100 acft of average annual outdoor demand. The median 2010-2017 rainwater harvesting amount of 42 acre-feet meets 42-48% of this demand (Table 6.1).

Table 6.1: Annual HND supply compared to average outdoor demand.

Mar-Oct	2010	2011	2012	2013	2014	2015	2016	2017	Median
HND supply (ac-ft)	19.2	45.3	26.3	42.4	52.7	58.1	29.5	41.6	42.0
% of full demand	22%	51%	30%	48%	60%	66%	34%	47%	48%
% of half demand	44%	103%	60%	96%	120%	132%	67%	95%	95%

Assuming that a water-smart household uses 50% of this average outdoor use estimate, the annual outdoor demand in the example development would be 44-50 acft. In this case, the median allowed rainwater harvesting almost fully meets demand, and 5 of the 8 years at Sterling Ranch would nearly meet or exceed this demand estimate. Outdoor water use in pilot projects may be even lower than these estimates due to the combination of landscaping and irrigation system design. These estimates from Sterling Ranch precipitation demonstrate the potential for rainwater harvesting to meet outdoor water demand in Colorado. Ultimately, beneficial use of rainwater harvested at pilot projects will depend on actual precipitation, storage pond size, and operations, and demand will depend on residential layout, landscaping, and irrigation. The sizing and usage of harvest facilities, as well as design and operation of the non-potable irrigation systems, are beyond the scope of this memo.

[30] Fact Sheet No. 9.952: Water Conservation In and Around the Home. Colorado State University, 2014.

[31] Outdoor water demand in a pilot project will be less than the Colorado average due to Criteria and Guidelines requirements of water-smart landscaping and efficient irrigation.