

Agenda

- ❑ **Why a Water Balance Forum** – *introduce framework for water-resilient communities*
- ❑ **Water Balance Express for Landowners** –
 - *unveil the first three to be implemented in this region:*
 - ✓ North Van District
 - ✓ Surrey
 - ✓ Coquitlam
 - *process to operationalize the Express for more partners in BC and beyond*
- ❑ **Water Balance Methodology** –
explain how to implement lessons learned over past 15 years and establish watershed targets to mimic water balance
- ❑ **Sustainable Watershed Systems, through Asset Management** – *previews IREI work plan thru 2017*

In the next 5 slides learn....

1. **HOW** the Water Balance Methodology has evolved over the past decade
2. **HOW** the Water Balance Methodology compares to the latest innovation and requirements in Washington and California
3. **HOW** to develop and implement performance targets that mimic the natural Water Balance in the watershed and the stream

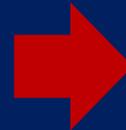
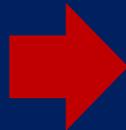
Watershed Health Goal:

Implementation of ***Standards of Practice*** that are ***Affordable and Effective*** in maintaining ***Healthy Watersheds and Streams***

Our vision is that the WBM Express will drive practices that “Mimic the Natural Water Balance”



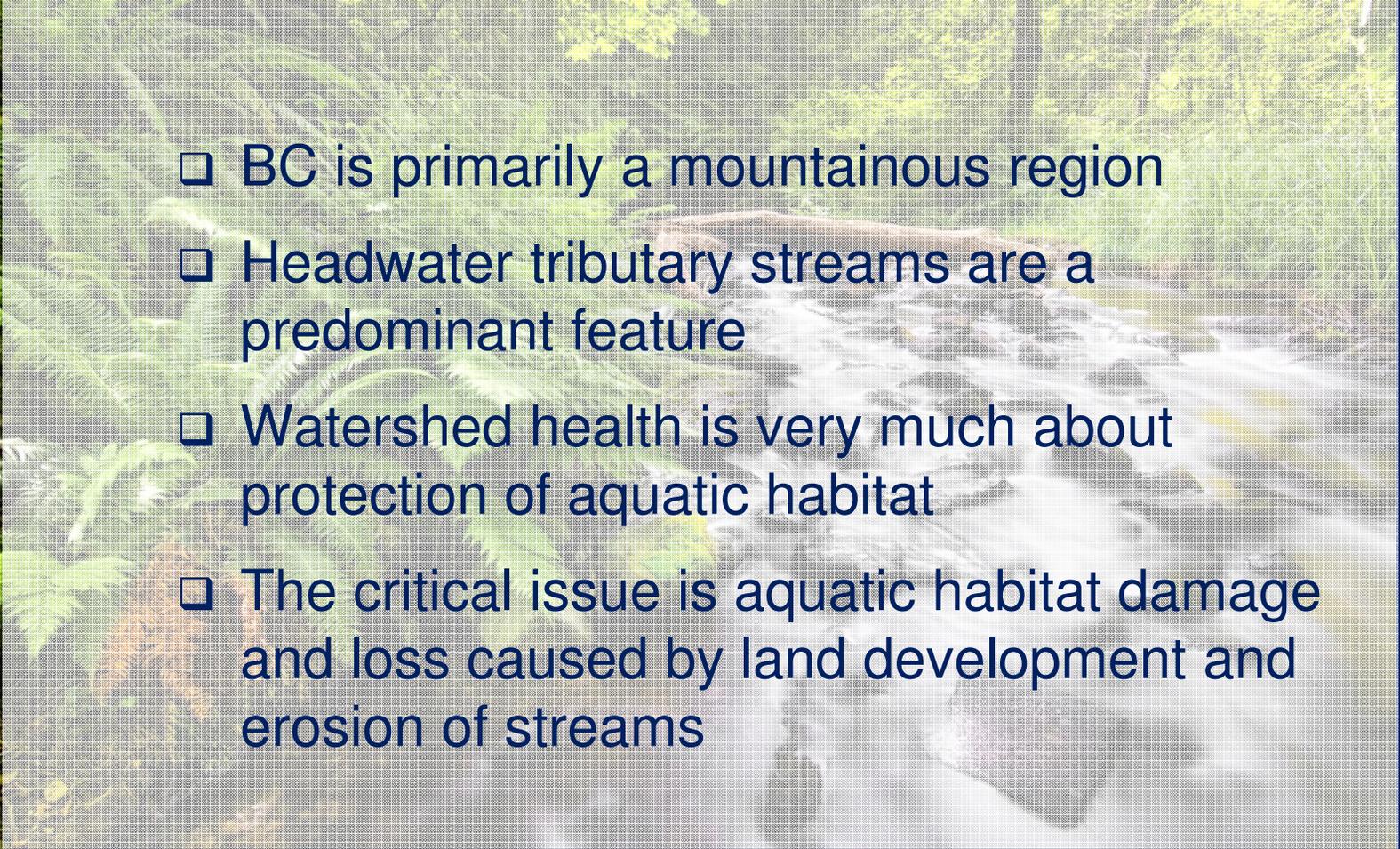
From natural....



..to initial development and then densification

THE GOAL: After development, the site will function as it did before, or better!

In BC, the Watershed Health Goal differs from that in other regions in that:

- 
- ❑ BC is primarily a mountainous region
 - ❑ Headwater tributary streams are a predominant feature
 - ❑ Watershed health is very much about protection of aquatic habitat
 - ❑ The critical issue is aquatic habitat damage and loss caused by land development and erosion of streams

THE SOLUTION: Look at Rainfall Differently

BC was the 1st jurisdiction in North America to adopt the 'Water Balance Methodology'

Released in 2002, the Guidebook is embedded in Liquid Waste Management Plan requirements

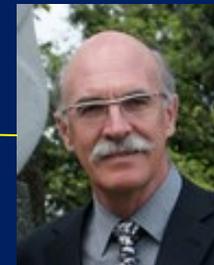


Stormwater Planning

- ❑ Translated Science-Based Understanding
- ❑ Introduced the Rainfall Spectrum
- ❑ Introduced “Retain, Detain, Convey” Strategy
- ❑ Formalized Performance Target Approach
- ❑ Established Adaptive Management Precedent
- ❑ Initiated Paradigm-Shift to Rainwater Management

Linking Rainfall, the Landscape, Streamflow and Groundwater has been a Building Block Process

- 2002 – How to reduce runoff volume
(Province - Stormwater Guidebook) ←
- 2007 – How to mimic flow-duration
(City of Surrey - Fergus Creek Plan) ←
- 2012 – How to sustain deep infiltration
(Parksville – Englishman River Research) ←
- 2013 – How to integrate performance targets
(Cowichan Valley & North Vancouver - case studies)
- 2014 – Water Balance Methodology
(downscaling watershed targets to a site level)
- 2015 – Beyond the Guidebook 2015



Dr. Gilles Wendling

In the next 12 slides you will learn....

1. **HOW** the Water Balance Methodology has evolved over the past decade
2. **HOW** the Water Balance Methodology compares to the latest innovation and requirements in Washington State and California
3. **HOW** to develop and implement performance targets that mimic the natural Water Balance in the watershed and in the stream

What is happening in these places?

- **Washington State Requirements**



- **The recent requirements in California**



- **In British Columbia**





- 2001 Introduced a Flow Duration approach
- Western Washington Stormwater Manual
 - 2012 Mandated the Flow Duration approach
 - “Stormwater discharges shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 8% of the 2-year peak flow to 50% of the 2-year peak flow.”
 - Note this is at a site level

Quotes are courtesy of the
Department of Ecology



“How LID Works”

- “Uses long-term on-site infiltration and evapotranspiration to reduce stormwater runoff.”
 - This is all about continuous simulation spanning years to derive solutions
- “What happens between storm events is more important than what happens during storm events”
 - This is very different from pipe design standard design practice

Quotes are courtesy of the
Department of Ecology

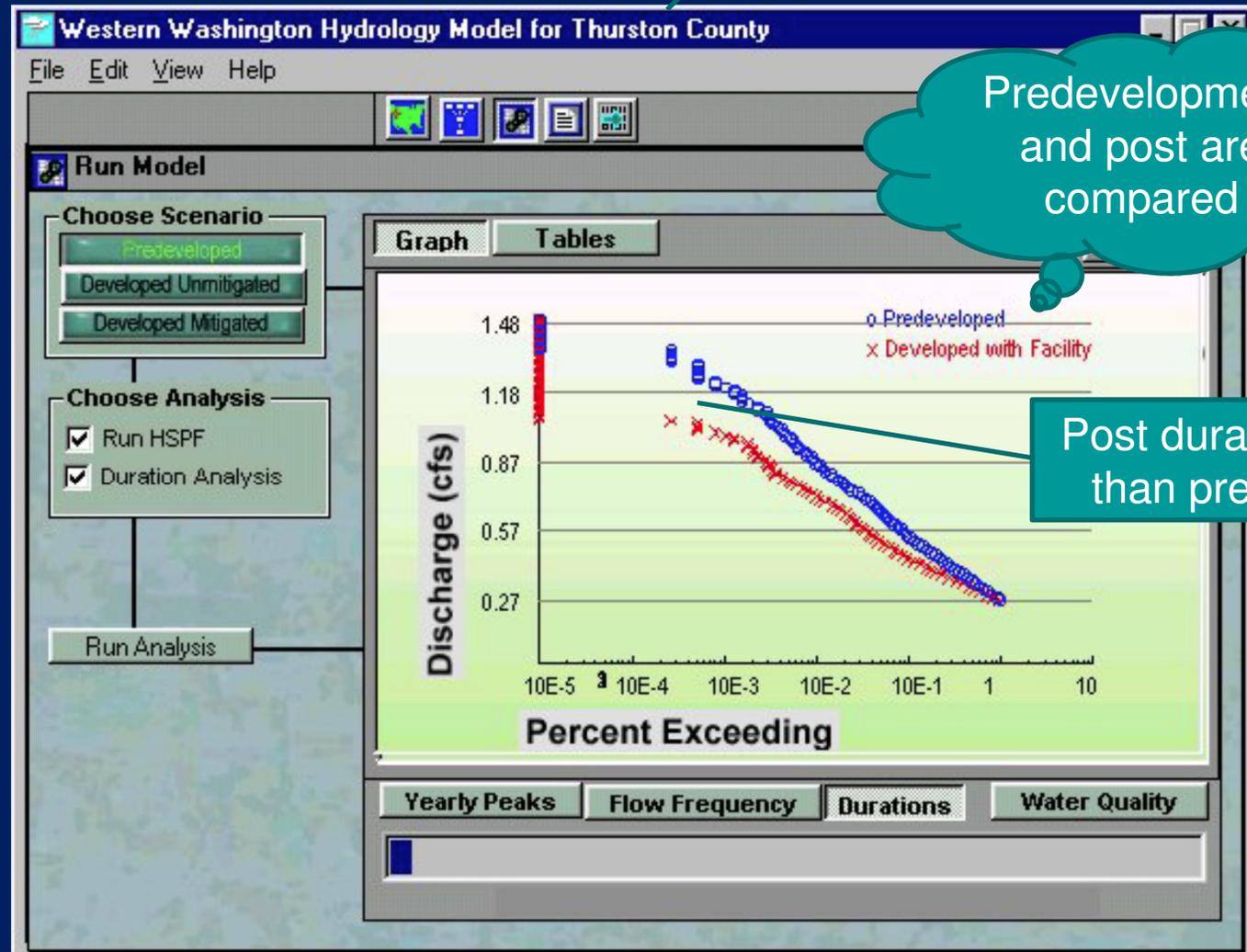


“Flow Control Requirement”

- “Match discharge durations to pre-developed durations for the range of pre-developed flow rates from 50% of the 2-year flow through the 50-year flow for the site”

Note that this is done for each development

County rather than watershed



Predevelopment and post are compared

Post duration is less than pre duration



“Effects of Changes in Flows and Sediment Loads to Waterways

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Stream Erosion

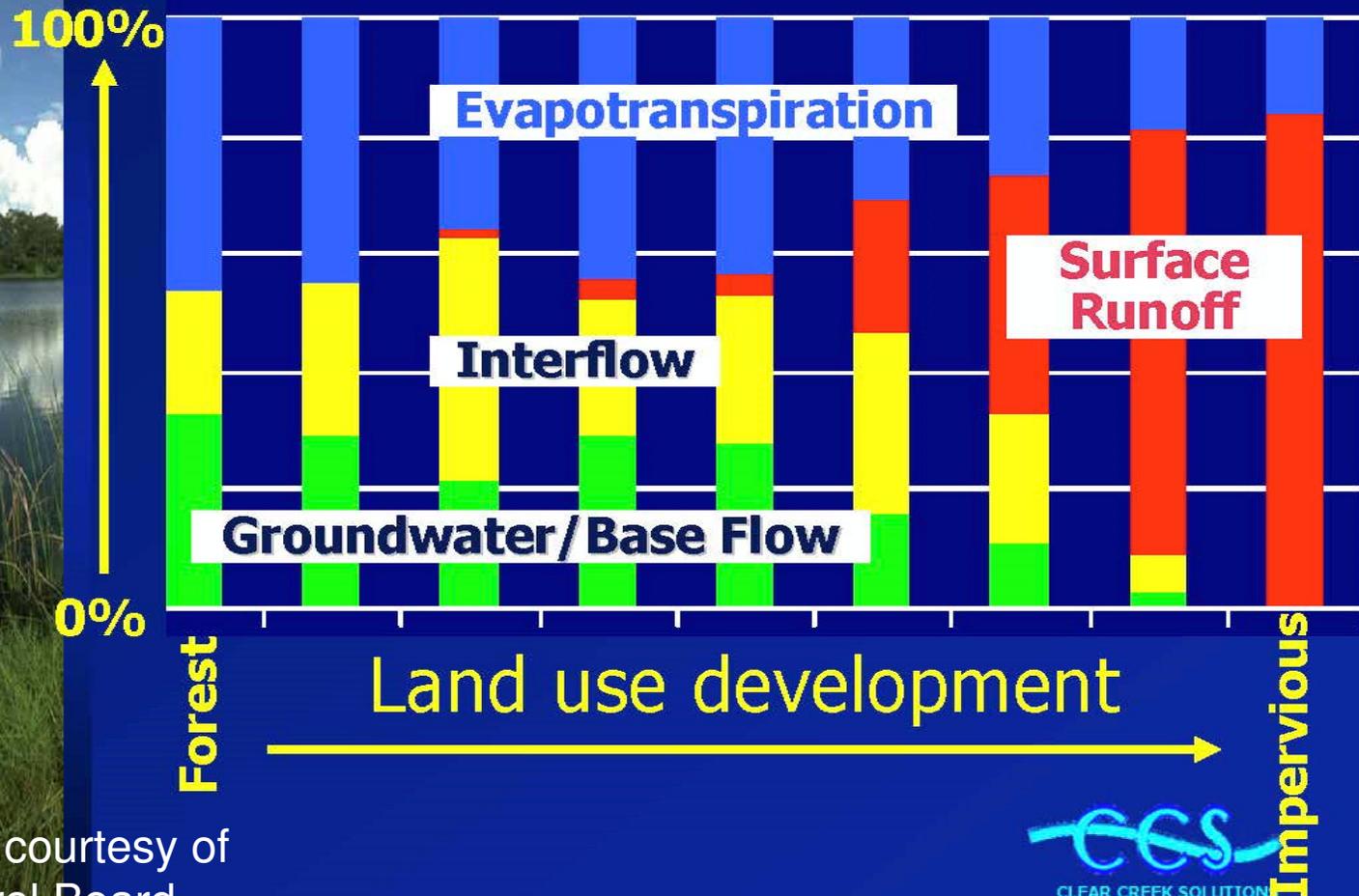


- “Includes “Flow Duration Analysis””
- “Continuous simulation hydrology models the entire hydrologic cycle for multiple years”
- “Single event modeling doesn’t work because:
 - Single-event flow frequency standards are based on inappropriate assumptions.
 - Single-event modeling cannot compute flow durations (percent of time flows exceed a specific value).
 - Flow duration range of concern is from 10% of the 2-year to 10-year flow event.”

Quotes are courtesy of the
WR Control Board



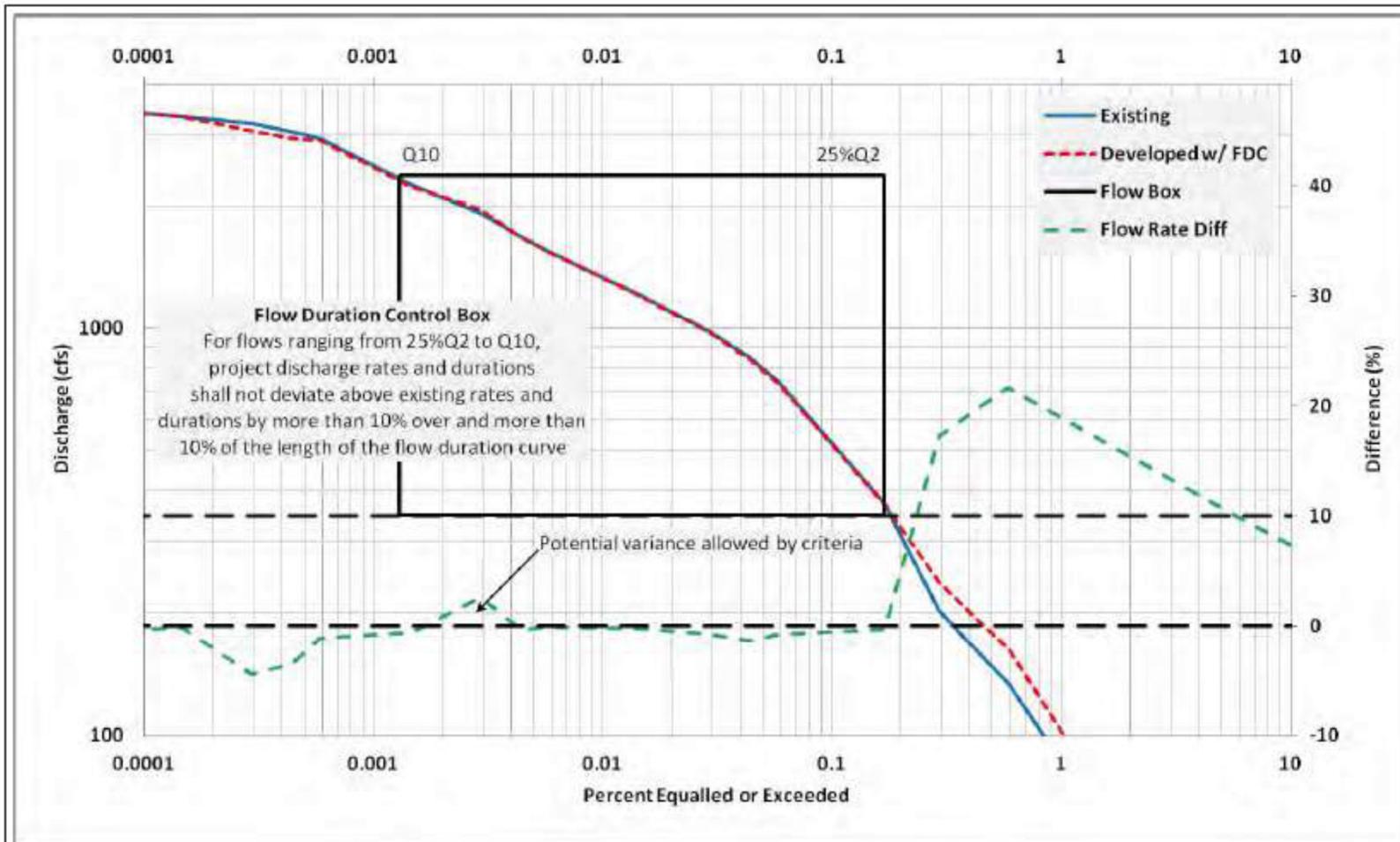
Where the rain goes:



Slide content courtesy of the WR Control Board



CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY STATE WATER RESOURCES CONTROL BOARD



Notes

Slide content courtesy of the WR Control Board



Guidance on the Use of Continuous Simulation Modeling

Example Flow Duration Curves

Project No. 11-1001

Created By: CRC

Figure 3-1



In British Columbia

- Learning from others
 - Utilizes all available scientific advances
- Recognize our geographic constraints
- Starts with the stream within a watershed
- Flow Duration is a basic part of Methodology
- Includes flood risk in the stream
- Establishes watershed targets for sites

FISHERIES AND OCEANS GUIDELINES – URBAN STORMWATER GUIDELINES AND BEST MANAGEMENT PRACTICES FOR PROTECTION OF FISH HABITAT (Revision 4)



“Hydrological Design

- Pre-development rates of runoff from developed and undeveloped sites will be modelled using public-domain hydrological analysis programs with **continuous simulation**”

Message – **use continuous simulation**

Washington, California, and British Columbia:

All three jurisdictions

- Address the impacts to a stream
- Use flow duration for stream protection
- Apply continuous simulation to model the entire hydrologic cycle for multiple years
- Recognize that single-event modeling does NOT work

In BC we

- Focus on watersheds rather than the development
- Are less restrictive which means it will likely cost less

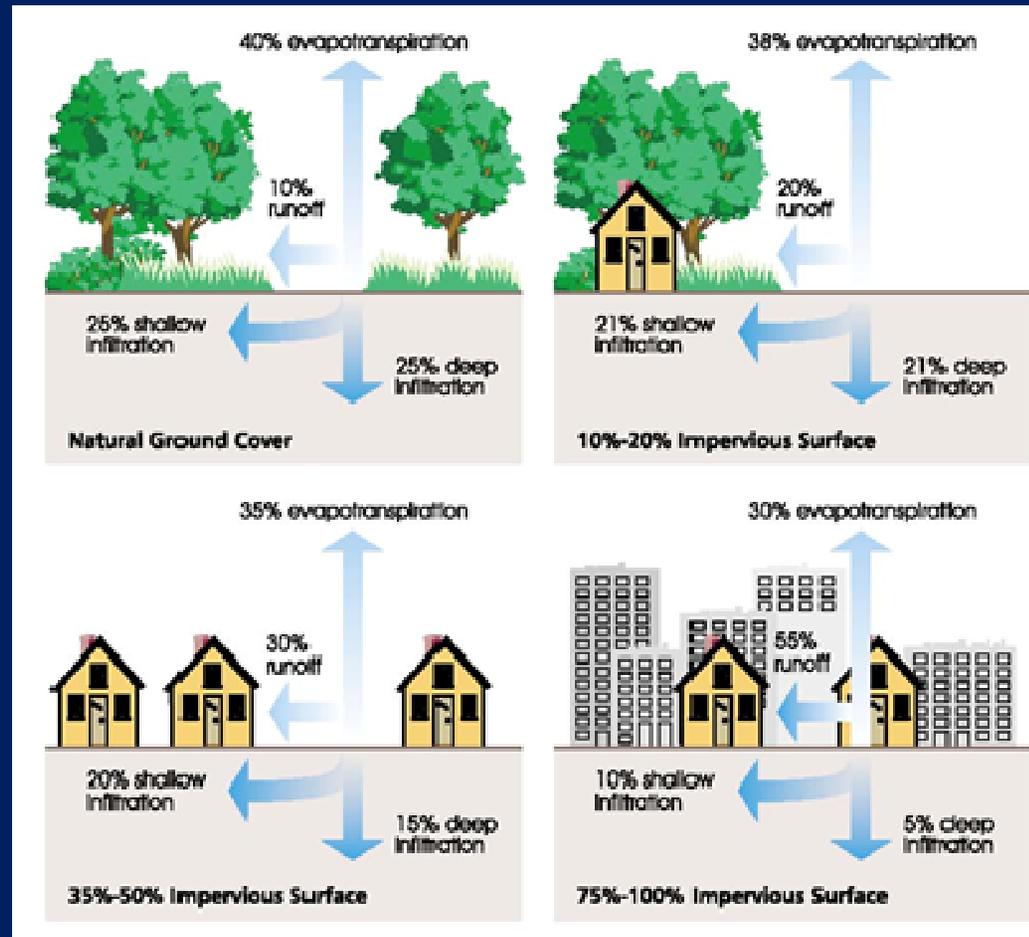
In the next 23 slides you will learn....

1. **HOW** the Water Balance Methodology has evolved over the past decade
2. **HOW** the Water Balance Methodology compares to the latest innovation and requirements in Washington State and California
3. **HOW** to develop and implement performance targets that mimic the natural Water Balance in the watershed and in the stream

In the next 4 slides:

You will learn about the three flow paths
rainwater follows to get to the stream

Knowledge Advances Over Time

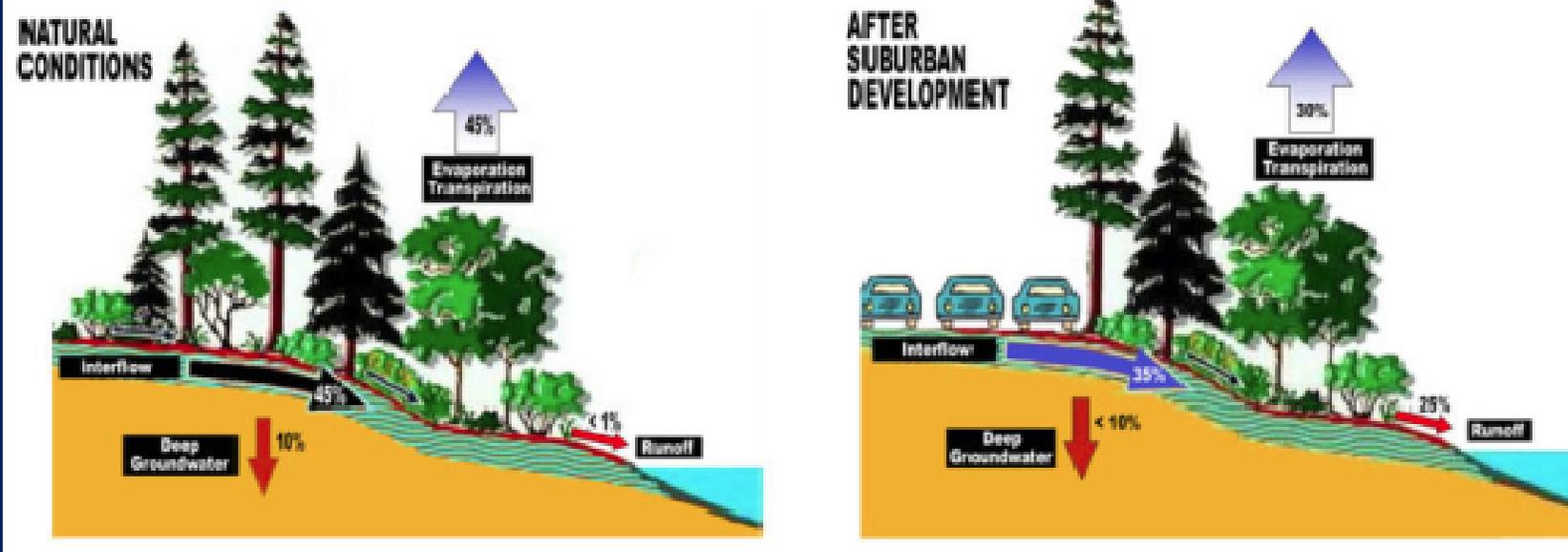


Source:

Low-Impact Development Hydrologic Analysis,
Prince George's County, Maryland July 1999

The headwater streams in BC have forced us to expand our view from the site to the watershed and stream.....

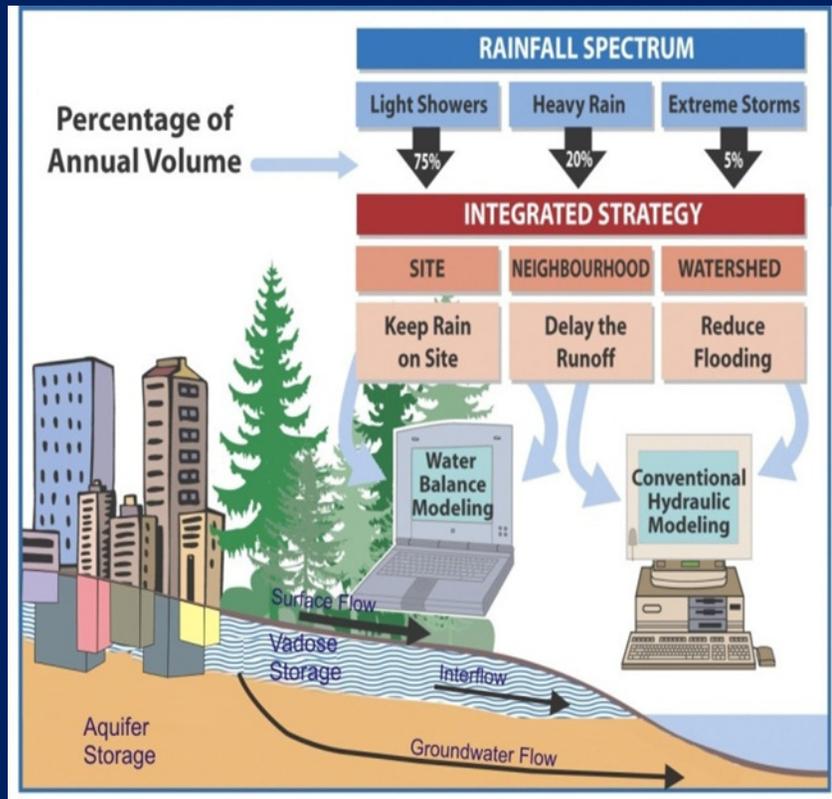
Example Annual Water Balance



Source: Stormwater Planning: A Guidebook for British Columbia, 2002

KEY MESSAGE: Guidebook identified the importance of *interflow* within the shallow vadose zone

Water Watershed protection starts with an understanding of how water gets to a stream, and how long it takes



Surface runoff

- *from minutes to hours*

Interflow

- *from days to seasons*

Deep Groundwater

- *from years to decades or more*

Maintain the proportion of rainwater entering the stream via each pathway!

Replicating interflow is incredibly important because....

These are typical West Coast annual water balance flow proportions:

- Rainfall → 100%
- Stream Discharge → 70% to 80% of Rainfall
 - Surface Runoff 10%
 - Aquifer recharge 10% up to 25%
 - Interflow 25% **up to 60%**
- Development reduces interflow

In the next 3 slides:

You will learn about infiltration and possible unintended consequences

Campbell Heights North, Surrey



For success develop and build on a gravel mine
- No storm sewers in this development

The experience of one Vancouver Island city illustrates why it is important to avoid unintended consequences



This experience reinforces the need for balance...



In the next 4 slides:

You will learn about the three water balance targets and how each is established

Objectives of Water Balance Methodology

- Flood Protection
- Maintain stream flows
 - Replace the lost interflow system
- Prevent stream erosion
- Prevent unforeseen impacts
- Improve water quality

Starts with the stream and ends with the stream

What is the “Baseflow Target” & How is it Established?

- Baseflow Target = Natural Stream Flow
= Mean Annual Discharge
(based on streamflow records)
- **A KEY MESSAGE:** “Green infrastructure” is necessary to replace lost interflow storage and flow pathways below ground

What is the “Volume Target” & How is it Established?

Water Balance Methodology addresses this question:

How much rainwater enters the stream, and
How does it enter the stream?

This is important because:

- Rain infiltrates and is **stored** in shallow soils.
It flows to stream through interflow
- Infrastructure is required to replace lost interflow storage and lost flow pathways below ground
- Streams need this flow and volume

What is the Volume Target & How is it Established?

Volume estimation is a balance because need:

1. Volume for Interflow Storage
2. Volume to Sustain Duration of Interflow
3. Volume to Allow Infiltration to Groundwater

Release from Storage to Sustain Base Flow

Infiltration **Area** to Support Deep Groundwater

What is the “Area Target” & How is it Established?

A guiding objective is to find the right percentage of surface area to promote deep infiltration because:

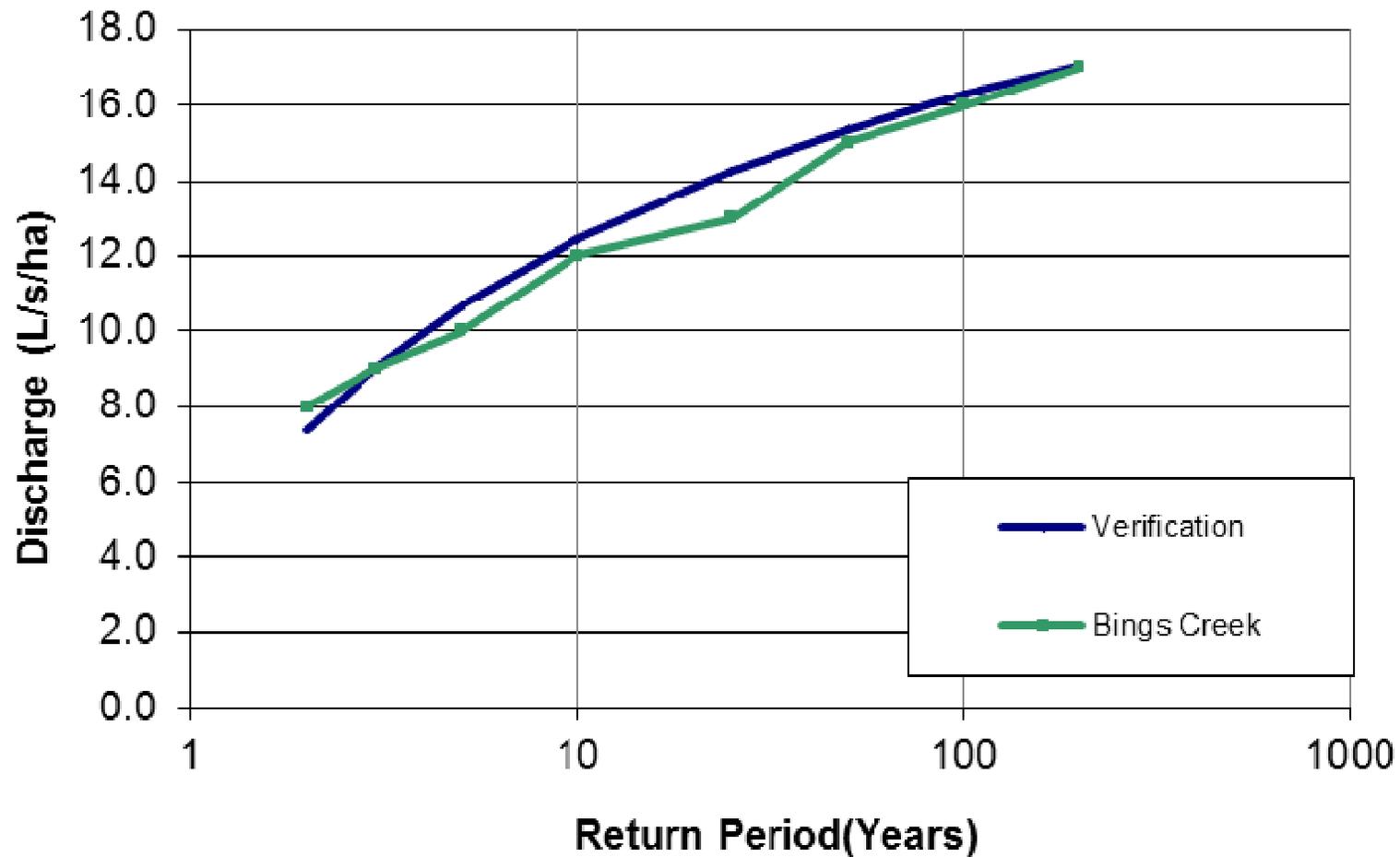
- Not all infiltrated water finds its way to deep groundwater
- Only a small portion of the land surface is directly connected to deep groundwater
- It is easy to either eliminate, or to amplify, flow to deep groundwater and thereby upset the natural Water Balance

In the next 3 slides:

You will learn what the results of the hydrologic analysis look like

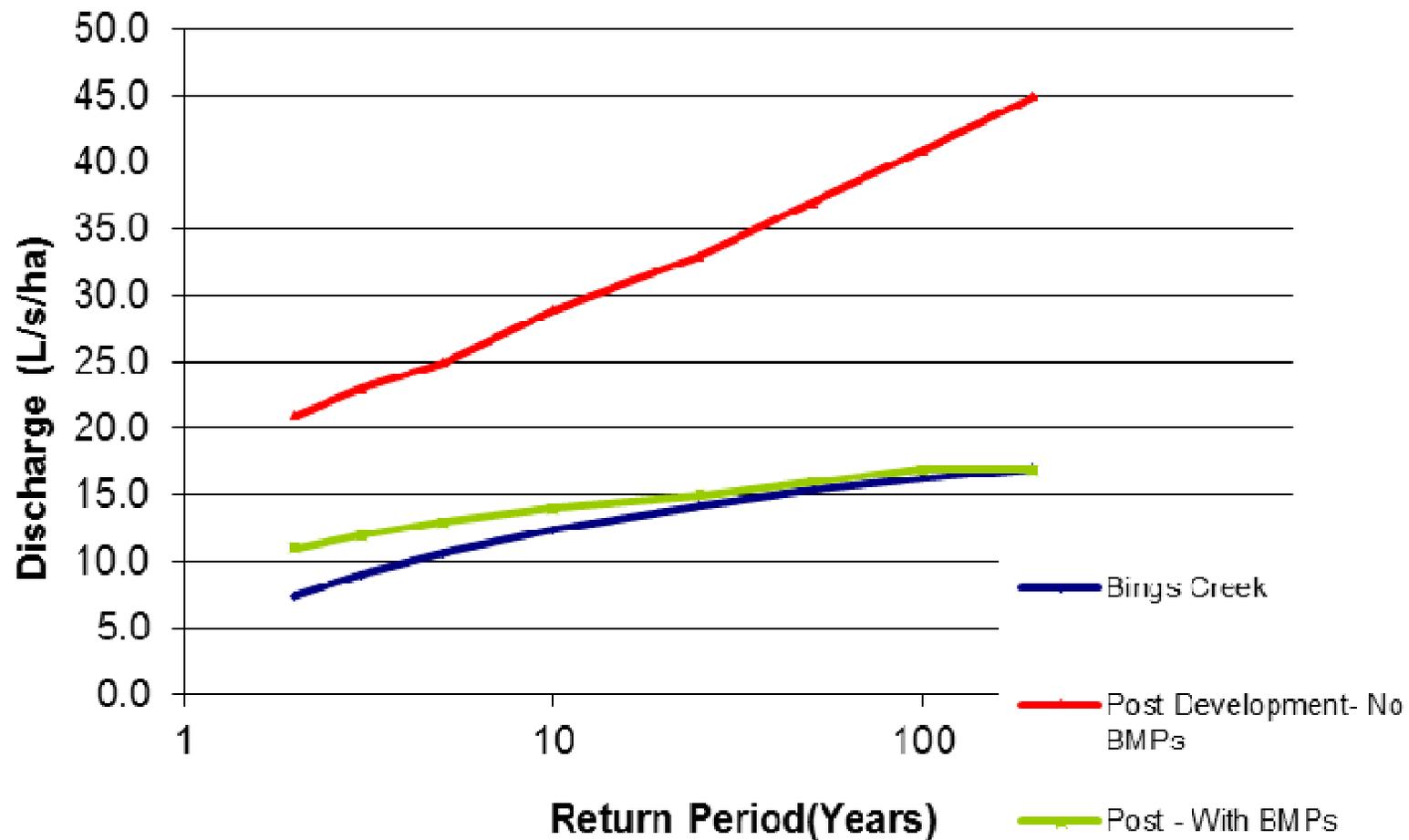
Model Calibration

Stream Flood Frequency

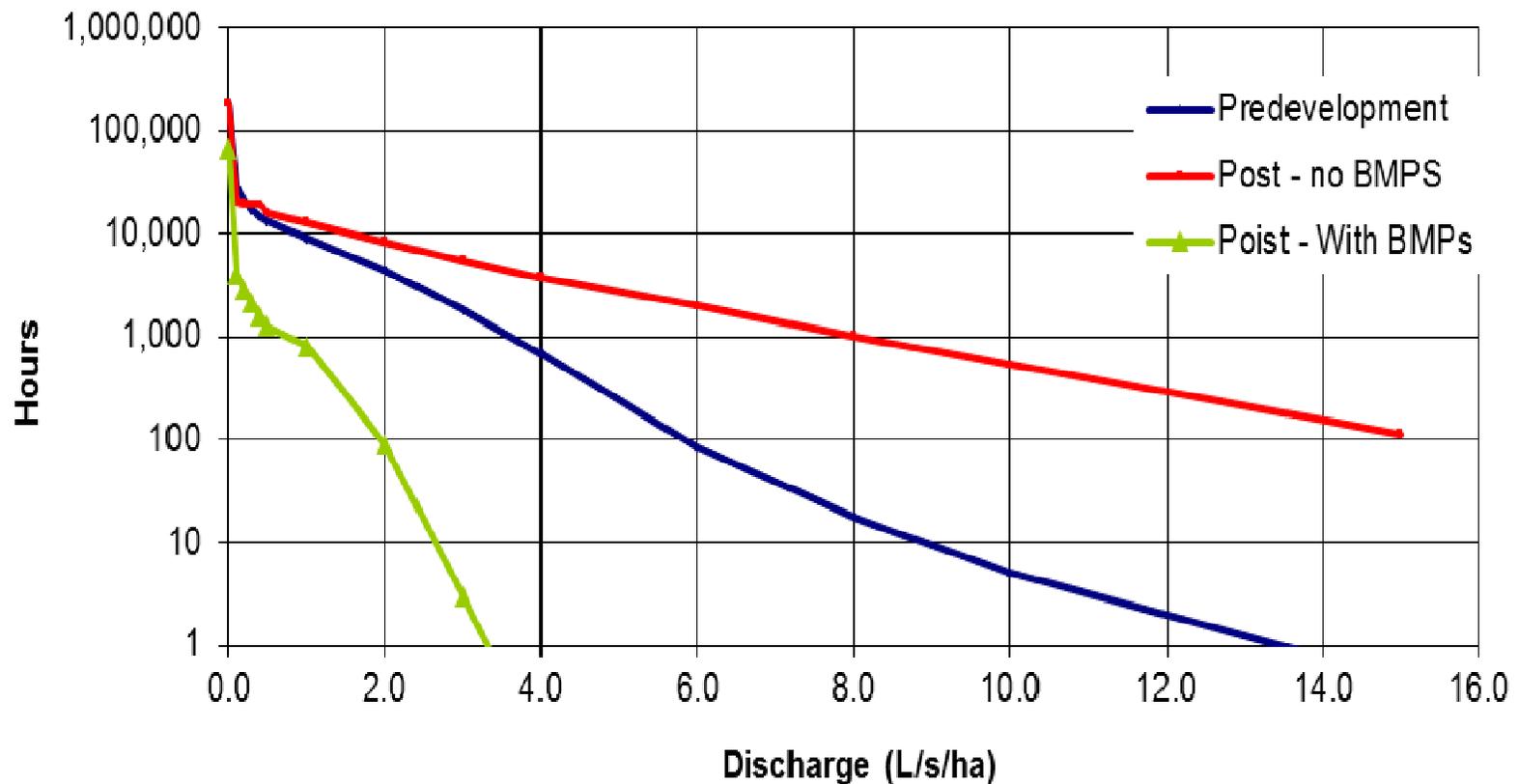


Flood Risk Mitigation

Stream Flood Frequency



Stream Impact Mitigation Flow Duration



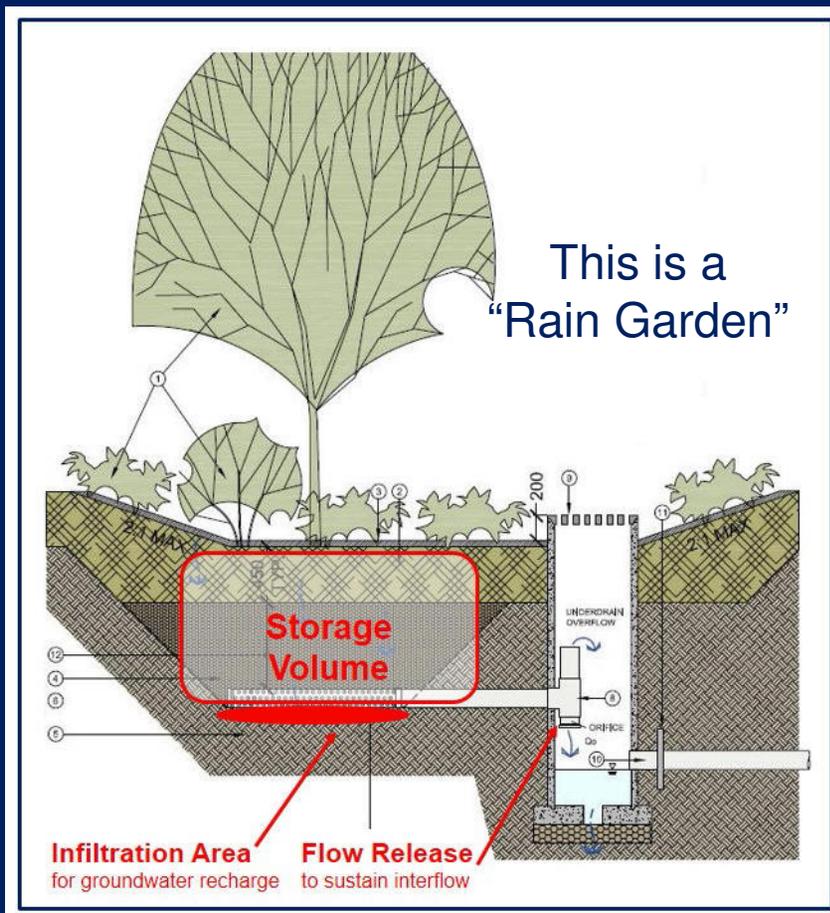
In the next 3 slides:

You will review the Water Balance Methodology and how it is implemented

In a nutshell, the Water Balance Methodology.....

- Applies science-based understanding to simplify complexity
- Synthesizes fundamentals of hydrology, flood protection aquatic ecology, geomorphology and hydrogeology
- Evolving to incorporate latest scientific knowledge
- Keyed to continuous simulation of watershed response to rainfall over the period of record
- Objective is to mimic stream flow and duration to limit stream erosion, prevent flooding, and improve water quality

How Volume, Release Rate and Area Targets are implemented at the site scale....



The WBM Express integrates and balances three targets:

- **Volume** for Interflow Storage
- **Release** to Sustain Duration of Interflow (to Mimic Shallow Groundwater flow)
- **Area** to Allow for Groundwater Recharge at Controlled Rates

How the site fits into the watershed

An illustration of how the Water Balance Methodology can be applied to establish targets for design of rainwater capture and flow release systems.....

Watershed-Specific Performance Targets

Target Parameter	Water Balance Function	Units of Measurement	Example Target Values*
Base Flow Release Rate	Interflow Replicator Rate	litres per second per hectare of drainage area	0.5
Storage Volume	Interflow Storage Replicator	cubic metres per hectare of hardened land surface	300
Infiltration Area	Groundwater Storage Recharge	percentage of project site area in contact with native ground	3%

*represents expected order-of-magnitude of target value

What did you learn?

1. **HOW** the Water Balance Methodology has evolved over the past decade
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3. **HOW** to develop performance targets that mimic the natural Water Balance in the watershed and the stream

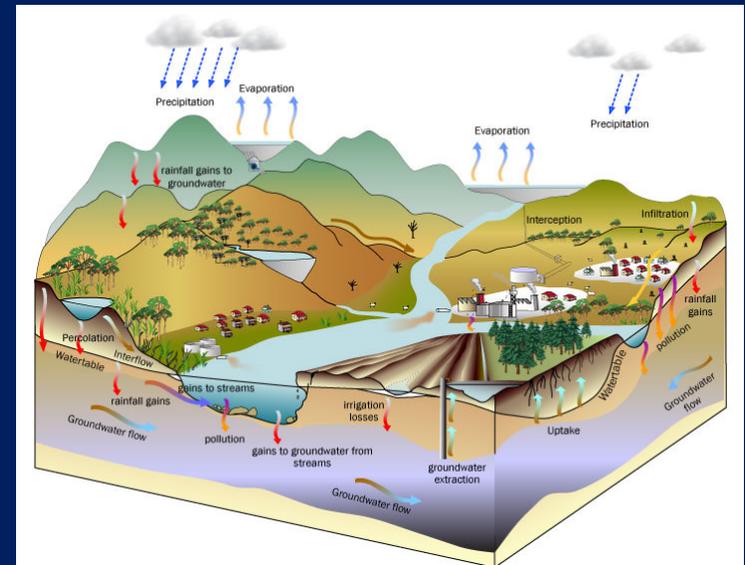
In the next 4 slides:

You will

- learn how to apply the Watershed Targets by implementing the Water Balance Express
- review key messages

Evolving science-based principles for restoring hydrologic integrity

1. Include “Flow-Duration Analysis”
2. Apply continuous simulation to model the entire hydrologic cycle for multiple years
3. Recognize that single-event modeling does NOT work



*Applying the “Water Balance Methodology”
is a Three-Step Process because.....*

STEP ONE: Complete watershed-scale analysis to establish watershed-based target values for the three Water Balance parameters: *storage volume, infiltration area and flow release rate*

STEP TWO: Customize WBM Express interface so that it is Partner-specific; and populate with target values

STEP THREE: Align roles and responsibilities within the Land Development Process and implement

Because there are three pathways to streams.....

- **KEY MESSAGE #1 -**

The Water Balance Methodology examines the flow paths of water in the watershed, and the flow in streams.

- **KEY MESSAGE #2 -**

At the heart of the Water Balance Methodology is recognition of the integrated significance of the three flow paths the period of time required for rainwater to reach the stream via each flow pathand the need to protect and maintain the natural distribution of rainwater via each flow path.

Because there are three pathways to streams.....

- **KEY MESSAGE #3 -**

Mitigation means replicate the shallow soil storage and interflow conveyance system in order to mimic the natural watershed.

- **KEY MESSAGE #4 -**

The analysis embodied in the Water Balance Methodology seeks to minimize the volume of retention and the infiltration system area while sustaining the base flow in streams.

Your Take Away Message

*The **Water Balance Methodology** provides a logical and straightforward way to assess potential watershed impacts resulting from urban development and analytically **demonstrate** the effectiveness of the methods proposed for preventing and/or mitigating those impacts in the **stream using flow duration.***

An Alternative Approach

