Infiltration is good. Infiltration returns the runoff to the ground, allowing it to slowly recharge the aquifer and the nearest stream. The ability to infiltrate runoff into the ground is included in most of the WWHM4 conveyance and storage elements.

There are two types of infiltration facilities: those that allow full infiltration and those that provide partial infiltration. With full infiltration there is no surface discharge; all of the water goes into the underlying soil. Partial infiltration has both surface and subsurface discharge.

The key to making infiltration work is having the right soils. Infiltration on the poorly draining soils is difficult because of their low infiltration rates. However, there are high infiltration soils (NRCS Type A and B soils) that are excellent for the use of infiltration facilities.

Infiltration of runoff is a recommended stormwater solution if certain conditions are met. These conditions include: a soils report, testing, groundwater protection, pre-settling, and appropriate construction techniques. There are times and places where too high infiltration rates, high groundwater tables, and groundwater mounding all can be problems and may make infiltration a poor choice for stormwater control. For these and other reasons it is important to first consult with the local permitting municipality to make sure that infiltration is allowed and that all of the standards and regulations are known.

For our project example we are going to size an infiltration facility first for full (100%) infiltration and then for partial (less than 100%) infiltration.

We will model a 10-acre site in Thurston County, Washington, near the city of Olympia. The first thing that we will do is to locate our project on the project map.
Our project site is located near the Olympia Airport in central Thurston County, Washington. We click on the map to select the project location. Based on our project location WWHM4 selects the appropriate precipitation record and precipitation multiplication factor. We then have the option to fill in the Site Information boxes.
Our predeveloped condition is 8 acres of forest on A/B soil on a flat slope and 2 acres of forest on C soil on a flat slope.
Our proposed development consists of 2 acres of roofs, 3 acres of roads, 1 acre of sidewalks, 1 acre of driveways, 2 acres of lawn on A/B soils, 0.75 acres of lawn on C soils, and a quarter-acre (0.25) set aside for the infiltration facility. All of the development is on a flat slope (0-5%). The WWHM4 trapezoidal pond element will be used to represent the infiltration facility.

We need to spend a minute to discuss how the infiltration pond surface area should be handled. We have two options:

1. We represent the pond surface area in the land use basin element as impervious area (as was done above). WWHM4 (and HSPF) then models the surface area as an impervious surface and computes the appropriate impervious surface runoff as input to the pond storage volume. For stormwater projects in the 19 Western Washington counties the Washington State Department of Ecology has decided to require that this is the appropriate option to use in this situation.

2. We do not represent the pond surface area in the land use basin element, but instead rain directly on and evaporate directly from the pond surface area in the pond element. For stormwater projects in Alameda, Santa Clara, and San Mateo counties in the San Francisco Bay Area (California) the county stormwater programs have decided that this is the appropriate option to use in this situation.
Technically, Option 2 is the most accurate way to model the infiltration pond surface area. However, because this project is in the Western Washington county of Thurston we will use Option 1 and include the pond surface area in the land use basin element area.

The next step is to size the infiltration pond. If we are sizing a partial infiltration pond (we will do that after we first size a full infiltration pond) we can use AutoPond, but AutoPond doesn’t work when there is no surface discharge from the pond with which to compute the flow durations values. Therefore, sizing a full infiltration pond requires a different process.
When we change Infiltration from NO to YES we have a new set of infiltration-related input to provide.
We enter the measured infiltration rate (inches per hour) for the infiltration pond. This is either the infiltration rate measured in the field or the infiltration rate specified by the reviewing agency. For this project we are using a measured infiltration rate of 10 inches per hour.

The infiltration reduction factor is a multiplier that is used with the measured infiltration rate to compute the actual infiltration rate used in WWHM4. The infiltration reduction factor is the inverse of a safety factor. For this project we are using an infiltration reduction factor of 0.25; that is equal to a safety factor of 4. The purpose of the safety factor is to adjust the infiltration to reflect its long-term rate. This is a function of the pretreatment of the inflow and maintenance of the infiltration facility. Check with the reviewing/permitting agency to find out what infiltration reduction/safety factor they want used in their jurisdiction.

The actual infiltration rate used in WWHM4 is the measured infiltration rate multiplied by the infiltration reduction factor. Our measured infiltration rate is 10 inches per hour; our infiltration reduction factor is 0.25. This produces an actual infiltration rate of 2.5 inches per hour (10 * 0.25 = 2.5).

Infiltration occurs through the pond’s bottom surface area. The sloped sides of the pond can also infiltrate water and the user can turn on this option by clicking on the “Use Wetted Surface Area (sidewalls)” down arrow to change NO to YES. Once again, check with the jurisdiction to see if they allow the use of the wetted surface area (side slopes) to
size the infiltration pond. Not all jurisdictions allow this assumption. We will leave “Use Wetted Surface Area (sidewalls)” set to NO.

WWHM4 has an algorithm designed to automatically size an infiltration pond based on a target percent infiltrated (provided by the user). We will leave the target percent at 100% because we are sizing the pond for full (100%) infiltration.

Before we click on the “Size Infiltration Pond” button we need to provide some additional information about the infiltration pond.

We have to give WWHM4 the initial bottom length and width, pond effective depth, and outlet structure information.

We have initially set aside one quarter of an acre for the pond area. That is equal to 10,890 square feet. We set the bottom width to 100 feet and the bottom length to 108.9 feet to equal a bottom area of 10,890 square feet.

The pond effective depth is the maximum depth allowed. We set that depth to 4 feet.

We leave the side slopes at the default value of zero (H/V), which means that the pond has vertical sides.
The outlet structure consists of a riser. Any water going through the riser is a surface discharge. We don’t want any surface discharge, which means that we don’t want any water going through the riser. But we need to include it to handle any overflows if the pond is too small to provide 100% infiltration.

We set the riser height to 3 feet (one foot short of the effective pond depth) to give us one foot of freeboard. The riser diameter is arbitrarily set to 24 inches. We have a flat riser instead of a riser with a notch because we do not want any discharge through the riser until the water reaches a depth of 3 feet. For that same reason we do not include a bottom orifice.

Note that below the “Use Wetted Surface Area” box are the volume calculations for infiltration facilities. These volume calculations are made after we run the model and compute the runoff and infiltration.

The total volume infiltrated (acre-feet) is the total volume of the runoff over the entire simulation period (40+ years) that goes into the ground.

Total volume through riser (acre-feet) is the runoff that is surface discharge. Our 100% infiltration goal is to size the pond so that this number is zero.

Total volume through facility is the sum of both the volume infiltrated and the volume discharged from the riser.

Percentage infiltrated is the total volume infiltrated divided by the total volume. This value will equal 100% when there is zero runoff volume from riser and the total volume infiltrated equals the total volume.

We are now ready to size the infiltration facility. Remember: our goal is to size the pond so that 100% of the runoff infiltrates and 0% goes out through the riser weir.
We click on the “Size Infiltration Pond” button and WWHM4 iterates until it find the smallest pond dimensions that still produce 100% infiltration.
To achieve 100% infiltration we need a pond with bottom dimensions of 165.9 feet by 152.3 feet. This is larger than our initial dimensions of 108.9 feet by 100 feet. The new pond surface area is 25,267 square feet or 0.58 acres. We originally set aside only 0.25 acres so we will have to change our design to accommodate this larger infiltration pond.

Other than increasing the infiltration pond’s surface area, we do have two other options:

1. We can increase the pond depth and riser height to provide more storage for the same pond footprint. Currently the pond depth is 4 feet and the riser height is 3 feet.

2. We can design the infiltration pond for less than 100% infiltration. If we have partial infiltration then some of the runoff will go through the riser and exit the pond as surface discharge. This is okay as long as we still meet the flow duration requirements.

Let’s try Option 2 (partial infiltration). We will use AutoPond to determine how small we can make the infiltration pond.

Typically partial infiltration does not work very well if the entire project site is on high infiltrating (A or B) soils. This is because there is very little predevelopment runoff from these soils and the flow duration matching becomes very difficult, if not impossible.
When part of the site includes lower infiltrating (C or D) soils then partial infiltration becomes more viable. In our case, 80 percent of the project site is on A/B soils and 20 percent is on C soils. There may be enough predevelopment runoff (primarily from the C soil area) to make flow duration matching possible. We will give it a try.

We click on the “AutoPond” button to size the infiltration pond for partial infiltration.
We set the adjustment level (amount of optimization) to its highest level (5) and change the pond side slopes from the default 3 to 1 to 0 to 1 (vertical walls). Then we click “Create Vault”. Take a break while Auto Vault runs through its iterations. When it finishes we will look at the results.
The AutoPond partial infiltration results show a pond with a bottom length and width of 152.8 feet. This produces a pond surface area of 0.54 acres; that is not much smaller than the full infiltration results (0.58 acres).

If we look at the flow duration results in the Analysis window we see that the red Mitigated flow duration curve has much room for improvement to match (or get closer to) the blue Predeveloped flow duration curve at the bottom end of the curve. We can increase the bottom orifice diameter to increase the duration numbers of the lower end of the Mitigated flow duration curve.
We increase the bottom orifice diameter from 1.2 inches to 2.0 inches to increase the lower discharge flows. We make the riser notch very small because if too much water goes through the notch then we increase the flows at the upper end of the flow duration curve and we don’t have much extra room at the upper end for more flows.

We click on “Run Scenario” to manually run the model. Then we can look at the flow duration results in the Analysis window.
We have improved the Mitigated flow duration curve with these changes to the outlet structure dimensions. We can now go back to AutoPond and use the Optimize feature to reduce the size of the infiltration pond.
When we use “Optimize Pond” to optimize a pond (any pond with or without infiltration) WWHM4 will take the existing pond facility dimensions and outlet structure data and use that information as its starting condition. We do not have to set the level of optimization (the slider at the top) because AutoPond will automatically use the highest level of optimization when we click on the “Optimize Pond” button. However, because our infiltration pond has vertical side walls we need to change the pond side slopes from the default value of 3 to the new value of 0.

We click “Optimize Pond” and stand back and watch the action.
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Using Optimize Pond and our initial bottom length and width of 152.8 feet, we reduced these dimensions to 151.0 feet. This corresponds to a surface area of 0.523 acres. This is not a great improvement over our previous pond size, but every little bit helps.

To summarize:

1. We initially size aside 0.250 acres for the infiltration pond area.

2. We designed an infiltration pond with full (100%) infiltration. The pond surface area had to be expanded from 0.250 acres to 0.580 acres.

3. We sized the infiltration pond for partial infiltration using AutoPond’s Create Pond feature. This action reduced the pond surface area from 0.580 acres to 0.536 acres.

4. We adjusted the infiltration pond riser orifice and notch dimensions and then used the Optimize Pond feature of AutoPond to make the pond smaller. This reduced the pond surface area from 0.536 acres to 0.523 acres.

Partial infiltration makes the infiltration pond smaller, but the decrease in pond size is highly dependent on the relative amount of high and low infiltrating soils draining to the pond and the proportion of impervious to pervious area in the Mitigated development scenario. Partial infiltration works best in low infiltrating soils and relatively small amounts of impervious area.
SUMMARY:
1. Locate project site on map.
2. Input Predeveloped and Mitigated land use information for the project basin. Connect Predeveloped basin to POC 1. Manually Predeveloped scenario.
3. Add a pond to Mitigated scenario. Connect pond to POC 1.
4. Input initial pond dimensions, riser information, and infiltration data.
5. For full (100%) infiltration click on “Size Infiltration Pond”.
6. For partial (less than 100%) infiltration use AutoPond to size the infiltration pond.
7. First use the Create Pond option in AutoPond to generate pond dimensions and outlet configuration data.
8. Look at flow duration curves in Analysis window.
9. Adjust outlet configuration data if necessary and use Optimize Pond to further reduce pond size.
10. Look at Report project report results.
11. Finished.