Water Balance Landscape Output Files

We refer to the landscape as any object related to hru's which includes soil and plant processes. Landscape units are the area weighted sum of hru's and are typically defined as subbasins. The basin output file is the area weighted sum of all hru's in the basin. Each variable is reported in mm summed over the time step, for the day, month, or year. Average annual is the total sum divided by the number of years of simulation. All timesteps outputs start after the skipped years. The curve number variable is averaged over the time period and is dimensionless.

The output files use the same naming convention starting with the object followed by the water balance, and then the time step (day, mon, yr and aa). For example, the average annual water balance output text file for hru's is hru_wb_aa.txt.

basin_wb_*.txt
lsunit_wb_*.txt
hru_wb_*.txt
hru-lte_wb_*.txt

```
 real :: precip = 0.       !mm H2O       |precipitation falling as rain and snow
 real :: snofall = 0.      !mm H2O       |precipitation falling as snow, sleet or freezing rain
 real :: snomlt = 0.       !mm H2O       |snow or ice melting
 real :: surq_gen = 0.     !mm H2O       |surface runoff generated from the landscape
 real :: latq = 0.         !mm H2O       |lateral soil flow
 real :: wateryld = 0.     !mm H2O       |water yield – sum of surface runoff, lateral soil flow, and tile flow
 real :: perc = 0.         !mm H2O       |amt of water perc out of the soil profile & into the vadose zone in HRU during mon
 real :: et = 0.           !mm H2O       |actual evapotranspiration from the soil
 real :: tloss = 0.        !mm H2O       |not reported
 real :: eplant = 0.       !mm H2O       |plant transpiration
 real :: esoil = 0.        !mm H2O       |soil evaporation
 real :: surq_cont = 0.    !mm H2O       |surface runoff leaving the landscape
 real :: cn = 0.           !none         |average curve number value for timestep
 real :: sw_init = 0.      !mm H2O       |initial soil water content of soil profile at start of time step
 real :: sw_final = 0.     !mm H2O       |final soil water content of soil profile at end of time step
 real :: sw = 0.           !mm H2O       |average soil water content of soil profile
 real :: sw_300 = 0.       !mm H2O       |final soil water content of upper 300 mm at end of time step
 real :: snopack = 0.      !mm           |water equivalent in snow pack
 real :: pet = 0.          !mm H2O       |potential evapotranspiration
 real :: qtile = 0.        !mm H2O       |subsurface tile flow leaving the landscape
 real :: irr = 0.          !mm H2O       |irrigation water applied
 real :: surq_runon = 0.   !mm H2O       |surface runoff from upland landscape
 real :: latq_runon = 0.   !mm H2O       |lateral soil flow from upland landscape
```

```
 real :: overbank = 0.     !mm H2O       |overbank flooding from channels
 real :: surq_cha = 0.     !mm H2O       |surface runoff flowing into channels
 real :: surq_res = 0.     !mm H2O       |surface runoff flowing into reservoirs
 real :: surq_ls = 0.      !mm H2O       |surface runoff flowing onto the landscape
 real :: latq_cha = 0.     !mm H2O       |lateral soil flow into channels
 real :: latq_res = 0.     !mm H2O       |lateral soil flow into reservoirs
 real :: latq_ls = 0.      !mm H2O       |lateral soil flow into a landscape element
```

Nutrient Balance Landscape Output Files

We refer to the landscape as any object related to hru's which includes soil and plant processes. Landscape units are the area weighted sum of hru's and are typically defined as subbasins. The basin output file is the area weighted sum of all hru's in the basin. Each variable is reported in kg/ha summed over the time step, for the day, month, or year. Average annual is the total sum divided by the number of years of simulation. All timesteps outputs start after the skipped years.

The output files use the same naming convention starting with the object followed by the nutrient balance, and then the time step (day, mon, yr and aa). For example, the average annual water balance output text file for hru's is hru_nb_aa.txt.

basin_nb_*.txt
lsunit_nb_*.txt
hru_nb_*.txt
hru-lte_nb_*.txt

```
  real :: grazn = 0.           !kg N/ha       |total nitrogen added to soil from grazing
  real :: grazp = 0.           !kg P/ha       |total phosphorus added to soil from grazing
  real :: lab_min_p = 0.       !kg P/ha       |phosphorus moving from the labile mineral pool to the active mineral pool
  real :: act_sta_p = 0.       !kg P/ha       |phosphorus moving from the active mineral pool to the stable mineral pool
  real :: fertn = 0.           !kg N/ha       |total nitrogen applied to soil
  real :: fertp = 0.           !kg P/ha       |total phosphorus applied to soil
  real :: fixn = 0.            !kg N/ha       |nitrogen added to plant biomass via fixation
  real :: denit = 0.           !kg N/ha       |nitrogen lost from nitrate pool by denitrification
  real :: act_nit_n = 0.       !kg N/ha       |nitrogen moving from active organic pool to nitrate pool
  real :: act_sta_n = 0.       !kg N/ha       |nitrogen moving from active organic pool to stable organic pool
  real :: org_lab_p = 0.       !kg P/ha       |phosphorus moving from the organic pool to labile pool
  real :: rsd_nitorg_n = 0.    !kg N/ha       |nitrogen moving from the fresh organic pool (residue) to the nitrate (80%)
                                                          and active org(20%) pools
```

```
real :: rsd_laborg_p = 0.     !kg P/ha        |phosphorus moving from the fresh organic pool (residue) to the labile(80%)
                                               and org(20%) pools
real :: no3atmo = 0.          !kg N/ha        |nitrate added to the soil from atmospheric deposition (rainfall + dry)
real :: nh4atmo = 0.          !kg N/ha        |ammonia added to the soil from atmospheric deposition (rainfall + dry)
```

Losses from the Landscape Output Files

We refer to the landscape as any object related to hru's which includes soil and plant processes. Landscape units are the area weighted sum of hru's and are typically defined as subbasins. The basin output file is the area weighted sum of all hru's in the basin. Nutrient variables are reported in kg/ha and sediment variables are reported in t/ha summed over the time step, for the day, month, or year. Average annual is total sum divided by the number of years of simulation. All timesteps outputs start after the skipped years.

The output files use the same naming convention starting with the object followed by the nutrient balance, and then the time step (day, mon, yr and aa). For example, the average annual water balance output text file for hru's is hru_ls_aa.txt.

basin_ls_*.txt
lsunit_ls_*.txt
hru_ls_*.txt
hru-lte_ls_*.txt

```
real :: sedyld = 0.           !metric tons/ha   |sediment yield leaving the landscape caused by water erosion
real :: sedorgn = 0.          !kg N/ha          |organic nitrogen transported in surface runoff
real :: sedorgp = 0.          !kg P/ha          |organic phosphorus transported in surface runoff
real :: surqno3 = 0.          !kg N/ha          |nitrate NO3-N transported in surface runoff
real :: latno3 = 0.           !kg N/ha          |nitrate NO3-N transported in laterl soil flow
real :: surqsolp = 0.         !kg P/ha          |soluble phosphorus transported in surface runoff
real :: usle = 0.             !metric tons/ha   |sediment erosion predicted with the USLE equation
real :: sedmin = 0.           !kg P/ha          |mineral phosphorus leaving the landscape transported in sediment
real :: tileno3 = 0.          !kg N/ha          |nitrate NO3 in tile flow
```

Plant and Weather Output Files

We refer to the landscape as any object related to hru's which includes soil and plant processes. Landscape units are the area weighted sum of hru's and are typically defined as subbasins. The basin output file is the area weighted sum of all hru's in the basin. Leaf are index, plant biomass, surface plant residue, soil temperature, and climate variables are averaged over the time period. Plant stresses, nutrient uptake, and heat units are summed over the time step, for the day, month, or year. Average annual is total sum divided by the number of years of simulation. All timesteps outputs start after the skipped years.

The output files use the same naming convention starting with the object followed by the plant/weather designation and then the time step (day, mon, yr and aa). For example, the average annual water balance output text file for hru's is hru_pw_aa.txt.

basin_pw_*.txt
lsunit_pw_*.txt
hru_pw_*.txt
hru-lte_pw_*.txt

```
 real :: lai = 0.              !m**2/m**2     |average leaf area index during timestep
 real :: bioms = 0.            !kg/ha         |average total plant biomass during timestep
 real :: yield = 0.            !kg/ha         |harvested biomass yield (dry weight) during timestep
 real :: residue = 0.          !kg/ha         |average surface residue cover during timestep
 real :: sol_tmp = 0.          !deg C         |average temperature of soil layer 2 during timestep
 real :: strsw = 0.            !days          |limiting water (drought) stress
 real :: strsa = 0.            !days          |excess water (aeration) stress
 real :: strstmp = 0.          !days          |temperature stress
 real :: strsn = 0.            !days          |nitrogen stress
 real :: strsp = 0.            !days          |phosphorus stress
 real :: nplnt = 0.            !kg N/ha       |plant uptake of nitrogen
 real :: percn = 0.            !kg N/ha       |nitrate NO3-N leached from bottom of soil profile
 real :: pplnt = 0.            !kg P/ha       |plant uptake of phosphorus
 real :: tmx = 0.              !deg C         |average maximum temperature during timestep
 real :: tmn = 0.              !deg C         |average minimum temperature during timestep
 real :: tmpav = 0.            !deg C         |average of average daily air temperature during timestep
 real :: solrad = 0.           !MJ/m^2        |average solar radiation during timestep
 real :: wndspd = 0.           !m/s           |average windspeed during timestep
 real :: rhum = 0.             !none          |average relative humidity during timestep
 real :: phubase0 = 0.         !deg c         |base zero potential heat units
```

Aquifer Output Files

We model aquifers as geologic storage under soil (hru), channels, and reservoirs. The basin aquifer output file is the area weighted sum of all aquifer's in the basin. Water storage, water table depth, and nitrate storage are average over the time period. All other variables are reported in mm or kg summed over the time step, for the day, month, or year. Average annual is total sum divided by the number of years of simulation. All timesteps outputs start after the skipped years. Organic carbon and organic nitrogen are currently static.

The output files use the same naming convention starting with the object followed by the water balance, and then the time step (day, mon, yr and aa). For example, the average annual water balance output text file for aquifers is aquifer_wb_aa.txt.

basin_aqu_*.txt
aquifer_*.txt

```
 real :: flo = 0.        !mm         |lateral flow from aquifer
 real :: dep_wt = 0.     !m          |average depth from average surface elevation to water table
 real :: stor = 0.       !mm         |average water storage in aquifer during timestep
 real :: rchrg = 0.      !mm         |recharge entering aquifer from other objects
 real :: seep = 0.       !kg N/ha    |seepage from bottom of aquifer
 real :: revap = 0.      !mm         |plant water uptake and evaporation
 real :: no3 = 0.        !kg NO3-N   |average nitrate NO3-N mass stored in aquifer during timestep
 real :: minp = 0.       !kg         |mineral phosphorus transported in return (lateral) flow
 real :: cbn = 0.        !percent    |organic carbon in aquifer – currently static
 real :: orgn = 0.       !kg/ha      |organic nitrogen in aquifer – currently static
 real :: rchrg_n = 0.    !kg NO3-N   |nitrate NO3-N flowing into aquifer from another object –

 real :: nloss = 0.      !kg/ha      |nitrate NO3-N loss
 real :: no3gw           !kg N/ha    |nitrate loading to reach in groundwater
 real :: seepno3 = 0.    !kg         |seepage of no3 to next object
 real :: flo_cha = 0.    !mm H2O     |aquifer flow into channels
 real :: flo_res = 0.    !mm H2O     |aquifer flow into reservoirs
 real :: flo_ls = 0.     !mm H2O     |aquifer flow into a landscape element (hru or ru)
```

Channel, Reservoir, and Wetland Output Files

The same output variables and format is used for channels, reservoirs, and wetlands. A channel is defined as a flowing water body transporting water from one point to another. A reservoir is defined as a stationary water body sitting directly over an aquifer. There is no simulation of soil and plant processes. A wetland is defined as water ponding on an hru. If no water is ponding, the wetland functions exactly as an hru. The ponded water can evaporate, seep into the soil, or flow out of the wetland as simulated by the assigned decision table. The general structure of output files is the first print surface area, precipitation, evaporation, and seepage into an aquifer (seepage into the soil for a wetland). Then storage of all variables at the end of the time period, inflow of all variables, followed by outflow of all variables. The basin channel, reservoir, and wetland output files report the area weighted sum of all of each object's types in the basin.

Surface area and storage variables are output at the end of the time period. All inflow and outflow variables are summed over the time step, for the day, month, or year. Average annual is total sum divided by the number of years of simulation. All timesteps outputs start after the skipped years.

The output files use the same naming convention starting with the object followed by the water balance, and then the time step (day, mon, yr and aa). For example, the average annual water balance output text file for reservoirs is reservoir_wb_aa.txt.

basin_cha_*.txt
channel_sd_*.txt
basin_res_*.txt
reservoir_*.txt
basin_wet_*.txt
wetland_*.txt

```
 real :: area_ha = 0.            ! ha            |water body surface area
 real :: precip = 0.             ! ha-m          |precipitation on the water body
 real :: evap = 0.               ! ha-m          |evaporation from the water surface
 real :: seep = 0.               ! ha-m          |seepage from bottom of water body
 real :: flo_stor = 0.           ! m^3           |water stored at end of time period
 real :: sed_stor = 0.           ! metric tons   |sediment stored at end of time period
 real :: orgn_stor = 0.          ! kg N          |organic N stored at end of time period
 real :: sedp_stor = 0.          ! kg P          |organic P stored at end of time period
 real :: no3_stor = 0.           ! kg N          |NO3-N stored at end of time period
 real :: solp_stor = 0.          ! kg P          |mineral (soluble P) stored at end of time period
 real :: chla_stor = 0.          ! kg            |chlorophyll-a stored at end of time period
 real :: nh3_stor = 0.           ! kg N          |NH3-N (ammonium) stored at end of time period
 real :: no2_stor = 0.           ! kg N          |NO2-N (nitrite) stored at end of time period
```

```
real :: cbod_stor = 0.          ! kg            |carbonaceous biological oxygen demand stored at end of time period
real :: dox_stor = 0.           ! kg            |dissolved oxygen stored at end of time period
real :: san_stor = 0.           ! tons          |detached sand stored at end of time period
real :: sil_stor = 0.           ! tons          |detached silt stored at end of time period
real :: cla_stor = 0.           ! tons          |detached clay stored at end of time period
real :: sag_stor = 0.           ! tons          |detached small ag stored at end of time period
real :: lag_stor = 0.           ! tons          |detached large ag stored at end of time period
real :: grv_stor = 0.           ! tons          |gravel stored at end of time period
real :: temp_stor = 0.          ! deg c         |water temperature
real :: flo_in = 0.             ! m^3           |water in
real :: sed_in = 0.             ! metric tons   |sediment in
real :: orgn_in = 0.            ! kg N          |organic N in
real :: sedp_in = 0.            ! kg P          |organic P in
real :: no3_in = 0.             ! kg N          |NO3-N (nitrate) in
real :: solp_in = 0.            ! kg P          |mineral (soluble P) in
real :: chla_in = 0.            ! kg            |chlorophyll-a in
real :: nh3_in = 0.             ! kg N          |NH3-N (ammonium) in
real :: no2_in = 0.             ! kg N          |NO2-N (nitrite) in
real :: cbod_in = 0.            ! kg            |carbonaceous biological oxygen demand in
real :: dox_in = 0.             ! kg            |dissolved oxygen in
real :: san_in = 0.             ! tons          |detached sand in
real :: sil_in = 0.             ! tons          |detached silt in
real :: cla_in = 0.             ! tons          |detached clay in
real :: sag_in = 0.             ! tons          |detached small ag in
real :: lag_in = 0.             ! tons          |detached large ag in
real :: grv_in = 0.             ! tons          |gravel in
real :: temp_in = 0.            ! deg c         |temperature in
real :: flo_out = 0.            ! m^3           |water out
real :: sed_out = 0.            ! metric tons   |sediment out
real :: orgn_out = 0.           ! kg N          |organic N out
real :: sedp_out = 0.           ! kg P          |organic P out
real :: no3_out = 0.            ! kg N          |NO3-N out
real :: solp_out = 0.           ! kg P          |mineral (soluble P) out
real :: chla_out = 0.           ! kg            |chlorophyll-a out
real :: nh3_out = 0.            ! kg N          |NH3-N (ammonium)  out
real :: no2_out = 0.            ! kg N          |NO2-N (nitrite)  out
real :: cbod_out = 0.           ! kg            |carbonaceous biological oxygen demand out
real :: dox_out = 0.            ! kg            |dissolved oxygen out
real :: san_out = 0.            ! tons          |detached sand out
real :: sil_out = 0.            ! tons          |detached silt out
real :: cla_out = 0.            ! tons          |detached clay out
real :: sag_out = 0.            ! tons          |detached small ag out
```

```
real :: lag_out = 0.            ! tons          |detached large ag out
real :: grv_out = 0.            ! tons          |gravel out
real :: temp_out = 0.           ! deg c         |temperature out
```

Channel Morphology Output Files

SWAT+ simulates channel downcutting and widening and gully morphology (gully erosion and head cut retreat). In addition to channel widening, downcutting, and slope adjustment, the channel morphology files output a detailed sediment budget. Total water inflow, aquifer inflow, and water outflow are output by rate (average daily m^3/s) and by volume (cumulative mm over the drainage area). The m^3/s units allow easy comparison to gage data while the mm unit is intuitive and can be compared with landscape runoff. The width, depth, and slope correspond to the end of each time step. Downcutting, widening, and head cut retreat are all total distances for the time period. All incoming and outgoing sediment loads (tons) are summed for the time period.

The output files use the same naming convention starting with the object followed by the water balance, and then the time step (day, mon, yr and aa). For example, the average annual water balance output text file for reservoirs is reservoir_wb_aa.txt.

basin_sd_chamorph_*.txt
channel_sdmorph_*.txt

```
real :: flo_in = 0.           ! (m^3/s)      |average daily inflow rate during time step
real :: aqu_in = 0.           ! (m^3/s)      |average daily aquifer inflow rate during time step
real :: flo = 0.              ! (m^3/s)      |average daily outflow rate during time step
real :: peakr = 0.            ! (m^3/s)      |average peak runoff rate during time step
real :: sed_in = 0.           ! (tons)       |sediment in
real :: sed_out = 0.          ! (tons)       |sediment out
real :: washld = 0.           ! (tons)       |wash load (suspended) out
real :: bedld = 0.            ! (tons)       |bed load out
real :: dep = 0.              ! (tons)       |deposition in channel and flood plain
real :: deg_btm = 0.          ! (tons)       |erosion of channel bottom
real :: deg_bank = 0.         ! (tons)       |erosion of channel bank
real :: hc_sed = 0.           ! (tons)       |erosion from gully head cut
real :: width = 0.            ! m            |channel bank full top width at end of time step
real :: depth = 0.            ! m            |channel bank full depth at end of time step
real :: slope = 0.            ! m/m          |channel slope
real :: deg_btm_m = 0.        ! (m)          |downcutting of channel bottom
real :: deg_bank_m = 0.       ! (m)          |widening of channel banks
real :: hc_m = 0.             ! (m)          |headcut retreat
real :: flo_in_mm = 0.        ! (mm)         |inflow rate total sum for each time step
real :: aqu_in_mm = 0.        ! (mm)         |aquifer inflow rate total sum for each time step
real :: flo_mm = 0.           ! (mm)         |outflow rate total sum for each time step
```

Point Source Output Files

SWAT+ allows users to input point sources (wastewater treatment plant waste or industrial waste), stream gage data, and simulated flows from other models. The point source files output the data at daily, monthly, yearly, and average annual time steps. The basin output aggregates all point sources in the simulation. Temperature is averaged over the time period and all other variables are summed.

The output files use the same naming convention starting with the object followed by the point source designation (psc), and then the time step (day, mon, yr and aa). For example, the average output text file for point sources is recall_aa.txt.

basin_psc_*.txt
recall_*.txt

```
 real :: flo = 0.              !! m^3           |volume of water
 real :: sed = 0.              !! metric tons   |sediment
 real :: orgn = 0.             !! kg N          |organic N
 real :: sedp = 0.             !! kg P          |organic P
 real :: no3 = 0.              !! kg N          |nitrate NO3-N
 real :: solp = 0.             !! kg P          |mineral (soluble P)
 real :: chla = 0.             !! kg            |chlorophyll-a
 real :: nh3 = 0.              !! kg N          |ammonium NH3-N
 real :: no2 = 0.              !! kg N          |nitrite NO2-N
 real :: cbod = 0.             !! kg            |carbonaceous biological oxygen demand
 real :: dox = 0.              !! kg            |dissolved oxygen
 real :: san = 0.              !! tons          |detached sand
 real :: sil = 0.              !! tons          |detached silt
 real :: cla = 0.              !! tons          |detached clay
 real :: sag = 0.              !! tons          |detached small ag
 real :: lag = 0.              !! tons          |detached large ag
 real :: grv = 0.              !! tons          |gravel
 real :: temp = 0.             !! deg c         |temperature
```

Object Hydrograph Output Files

The object hydrograph output files allow users to print specific hydrographs from specific objects. This is commonly used to: 1) print daily channel outflow to compare to a stream gage and 2) print daily flow to a file that can be read in as a point source from another SWAT+ simulation. A user could also output daily surface runoff, lateral flow, tile flow, or percolation from and an individual hru. The only timestep for the object hydrograph files is daily. In the object.prt file (or the file name given in file.cio), the user specifies the object type (hru, channel, reservoir, etc.), the object number, the hydrograph type, and the file name to write the output. The hydrograph type is object dependent. For example, an hru has 5 hydrograph types: total runoff (tot), surface runoff (sur), lateral soil flow (lat), tile flow (til), and percolation (rhg). Daily soil water (mm) for each soil layer can also be printed for an hru using the sol hydrograph type. Using object type 0 prints soil water for all hrus. A channel or reservoir has total flow out (tot) which can be used as a point source file without modification.

This is an example object.prt file:

NUMB	OBTYP	OBTYPNO	HYDTYP	FILENAME
1	hru	**1**	sur	**surf_hru1.out**
1	hru	**0**	sol	**soils_st.out**
1	sdc	**3**	tot	**flow_cha3.out**

Hydrograph Output

```
 real :: flo = 0.              !! m^3           |volume of water
 real :: sed = 0.              !! metric tons   |sediment
 real :: orgn = 0.             !! kg N          |organic N
 real :: sedp = 0.             !! kg P          |organic P
 real :: no3 = 0.              !! kg N          |nitrate NO3-N
 real :: solp = 0.             !! kg P          |mineral (soluble P)
 real :: chla = 0.             !! kg            |chlorophyll-a
 real :: nh3 = 0.              !! kg N          |ammonium NH3-N
 real :: no2 = 0.              !! kg N          |nitrite NO2-N
 real :: cbod = 0.             !! kg            |carbonaceous biological oxygen demand
 real :: dox = 0.              !! kg            |dissolved oxygen
 real :: san = 0.              !! tons          |detached sand
 real :: sil = 0.              !! tons          |detached silt
 real :: cla = 0.              !! tons          |detached clay
 real :: sag = 0.              !! tons          |detached small ag
 real :: lag = 0.              !! tons          |detached large ag
 real :: grv = 0.              !! tons          |gravel
 real :: temp = 0.             !! deg c         |temperature
```

Soil Water Output

Day/month/year	Layer 1(mm)	Layer 2(mm)	Layer 3(mm)	Layer 4(mm)	…