Appendix B. Manual for Functions and Datasets in the R-Package 'wrv'

This vignette is a reference manual for functions and datasets in the **wrv** package (version 1.1.2). A short description and R usage information (such as examples of how to use a function) are given for all functions and datasets. Dataset documentation include sections describing the format of a dataset (such as a vector or matrix) and details on the original or secondary data source. Functions and datasets are named according to the following conventions. The form for function names is no separator between words and initial capital letters (such as `GetSeasonalMult`); dataset names have words separated with dots and all lower case letters (such as `alluvium.extent`).

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---

alluvium.extent   *Extent of Alluvium Unit*

Description

Estimated extent of alluvium unit in the Wood River Valley aquifer system.

Usage

```
alluvium.extent
```

Format

An object of SpatialPolygonsDataFrame class containing 1 Polygons. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Extent defined by Bartollino and Adkins (2012, Plate 1).

References

Bartolino, J.R., and Adkins, C.B., 2012, Hydrogeologic framework of the Wood River Valley aquifer system, south-central Idaho: U.S. Geological Survey Scientific Investigations Report 2012-5053, 46 p., available at https://pubs.usgs.gov/sir/2012/5053/.

Examples

```
sp::plot(alluvium.extent, col = "#BFA76F")
str(alluvium.extent)
```

---

alluvium.thickness   *Thickness of the Quaternary Sediment*

Description

Estimated thickness of the Quaternary sediment in the Wood River Valley aquifer system.

Usage

```
alluvium.thickness
```

Format

An object of RasterLayer class. Each cell on the surface grid represents a depth measured from land surface in meters. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM). The spatial grid is composed of 565 rows and 429 columns, and has cell sizes that are constant at 100 meters by 100 meters.

Source

Revised version of Plate 1 in Bartolino and Adkins (2012).

References

Bartolino, J.R., and Adkins, C.B., 2012, Hydrogeologic framework of the Wood River Valley aquifer system, south-central Idaho: U.S. Geological Survey Scientific Investigations Report 2012-5053, 46 p., available at https://pubs.usgs.gov/sir/2012/5053/.

Examples

```
col <- rainbow(255, start = 0.0, end = 0.8)
raster::image(alluvium.thickness, col = col, asp = 1, axes = FALSE,
              xlab = "", ylab = "")
summary(alluvium.thickness)
```

---

basalt.extent   *Extent of Basalt Unit*

Description

Estimated extent of the basalt unit underlying the alluvial Wood River Valley aquifer system.

Usage

```
basalt.extent
```

Format

An object of SpatialPolygonsDataFrame class containing 1 Polygons. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Extent defined by Bartollino and Adkins (2012, Plate 1).

References

Bartolino, J.R., and Adkins, C.B., 2012, Hydrogeologic framework of the Wood River Valley aquifer system, south-central Idaho: U.S. Geological Survey Scientific Investigations Report 2012-5053, 46 p., available at https://pubs.usgs.gov/sir/2012/5053/.

Examples

```
sp::plot(basalt.extent, col = "#BEAED4", border = NA)
sp::plot(alluvium.extent, add = TRUE)
str(basalt.extent)
```

---

bellevue.wwtp.ponds   *Bellevue Waste Water Treatment Plant Ponds*

Description

Location of the Bellevue Waste Water Treatment Plant ponds.

Usage

```
bellevue.wwtp.ponds
```

Format

An object of SpatialPolygonsDataFrame class containing 1 Polygons. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources, accessed on December 11, 2014

Examples

```
sp::plot(bellevue.wwtp.ponds)
```

---

bypass.canal   *Bypass Canal*

Description

Location of the Bypass Canal in the Wood River Valley.

Usage

```
bypass.canal
```

Format

An object of SpatialLines class containing 4 Lines. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources, accessed on January 15, 2015

Examples

```
sp::plot(bypass.canal)
```

---

canal.seep   *Canal Seepage*

Description

Canal seepage as a fraction of diversions for irrigation entities in the Wood River Valley.

Usage

```
canal.seep
```

Format

An object of class data.frame with 19 records and the following variables:

EntityName name of the irrigation entity served by the canal system.

SeepFrac estimated canal seepage as a fraction of diversions.

Source

Idaho Department of Water Resources, accessed on November 4, 2015

See Also

[canals](#)

Examples

```
str(canal.seep)

d <- canal.seep[order(canal.seep$SeepFrac, decreasing=TRUE), ]
par(mar = c(4.1, 8.1, 0.1, 0.6))
barplot(d$SeepFrac, names.arg = d$EntityName, horiz = TRUE, cex.names = 0.7,
        cex.axis = 0.7, cex.lab = 0.7, las = 1, xlab = "Seepage fraction")

graphics.off()
```

---

canals   *Canal Systems*

Description

Canal systems in the Wood River Valley and surrounding areas.

Usage

```
canals
```

Format

An object of SpatialLinesDataFrame class containing 113 Lines and a data.frame with the following variable:

EntityName name of the irrigation entity served by the canal system.

Name local canal name

Source

Idaho Department of Water Resources, accessed on November 29, 2014

See Also

r.canals, canal.seep

Examples

```
sp::plot(canals, col = "#3399CC")
str(canals@data)
```

---

cities   *Cities and Towns*

Description

Cities and towns in the Wood River Valley and surrounding areas.

Usage

```
cities
```

Format

An object of SpatialPointsDataFrame class containing 11 points. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources (IDWR), accessed on April 15, 2015

Examples

```
str(cities)

col <- "#333333"
sp::plot(cities, pch = 15, cex = 0.8, col = col)
text(cities, labels = cities@data$FEATURE_NA, col = col, cex = 0.5, pos = 1, offset = 0.4)
```

---

clay.extent   *Extent of Clay Unit*

Description

Estimated extent of the clay confining unit (aquitard) separating the unconfined aquifer from the underlying confined aquifer in the Wood River Valley aquifer system.

Usage

```
clay.extent
```

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Format

An object of SpatialPolygonsDataFrame class containing 2 Polygons. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Extent defined by Moreland (1977, fig. 3 in USGS Open-File report). Moreland (1977) shows an outlier by Picabo that is assumed to indicate confined conditions in the basalt and not the lake sediments.

References

Moreland, J.A., 1977, Ground water-surface water relations in the Silver Creek area, Blaine County, Idaho: Boise, Idaho Department of Water Resources, Water Information Bulletin 44, 42 p., 5 plates in pocket, accessed January 31, 2012. Also published as U.S. Geological Survey Open-File report 77-456, 66 p., available at https://pubs.er.usgs.gov/publication/ofr77456.

Examples

```
sp::plot(clay.extent, col = "#FDC086", border = NA)
sp::plot(alluvium.extent, add = TRUE)
str(clay.extent)
```

---

comb.sw.irr   *Combined Surface-Water Irrigation Diversions*

Description

Supplemental groundwater rights and associated surface-water rights.

Usage

```
comb.sw.irr
```

Format

An object of class data.frame with 1,213 records and the following variables:

WaterRight name of the supplemental groundwater right.

CombWaterRight name of the surface-water right that shares a combined limit with the groundwater right.

Source river or stream source name for the surface-water right.

WaterUse authorized beneficial use for the surface-water right.

MaxDivRate authorized maximum diversion rate for the surface-water right, in cubic meters per day.

Pdate priority date of the surface-water right.

Source

Idaho Department of Water Resources (IDWR), accessed on April 25, 2014; derived from combined limit comments in IDWR water rights database.

Examples

```
str(comb.sw.irr)
```

---

div.gw   *Groundwater Diversions*

Description

Groundwater diversions recorded by Water District 37 or municipal water providers. Groundwater is diverted from the aquifer by means of either pumping wells or flowing-artesian wells.

Usage

div.gw

Format

An object of class data.frame with 7,292 records and the following variables:

YearMonth year and month during which diversions were recorded, with a required date format of YYYYMM.

Diversion name of the well

Reach name of the river subreach into which the well water is discharged; only applicable to exchange wells.

BigReach name of the river reach into which the well water is discharged; only applicable to exchange wells.

EntityName name of the irrigation entity which the well supplies water.

WMISNumber well number in the Idaho Department of Water Resources (IDWR) Water Measurement Information System.

GWDiv volume of water diverted during the month, in cubic meters.

Source

Idaho Department of Water Resources (IDWR), accessed on December 11, 2014; compiled data records from Water District 37 and 37M, City of Ketchum, Sun Valley Water and Sewer District, City of Hailey, and City of Bellevue.

Examples

str(div.gw)

---

div.ret.exch   *Diversions, Returns, and Exchange Wells*

Description

Location of streamflow diversions, irrigation canal or pond returns, and exchange well returns.

Usage

div.ret.exch

B10   Groundwater-Flow Model for the Wood River Valley Aquifer System, South-Central Idaho

Format

An object of SpatialPointsDataFrame class containing 117 points with the following variables:

Name local name for the diversion/return site.

Type data type, either "Diversion", "Return", or "Exchange well inflow".

LocSource data source

Big corresponding river reach

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources, accessed on June 5, 2015

Examples

```
sp::plot(div.ret.exch)
str(div.ret.exch@data)
```

---

div.sw   *Surface-Water Diversions*

Description

Surface-water diversions recorded by Water District 37 or municipal water providers.

Usage

```
div.sw
```

Format

An object of class data.frame with 15,550 records and the following variables:

YearMonth year and month during which diversions were recorded, with a required date format of YYYYMM.

Diversion name of the surface-water diversion.

Reach river subreach from which the water is diverted.

BigReach river reach from which the water is diverted.

EntityName name of the irrigation entity which the diversion supplies water.

SWDiv volume of water diverted during the month, in cubic meters.

Source

Idaho Department of Water Resources, accessed on December 11, 2014; compiled data records from Water District 37 and 37M, City of Hailey, City of Bellevue, City of Ketchum, and Sun Valley Water and Sewer District.

Examples

```
str(div.sw)
```

---

div.ww   *Wastewater Treatment Plant Diversions*

Description

Discharge from wastewater treatment plants.

Usage

```
div.ww
```

Format

An object of class data.frame with 1,182 records and the following variables:

YearMonth year and month during which diversions were recorded, with a required date format of YYYYMM.

Return name of the wastewater treatment plant.

Reach name of the river subreach to which treated effluent is discharged; only applicable to wastewater treatment plants that discharge to the river.

BigReach name of the river reach to which treated effluent is discharged; only applicable to wastewater treatment plants that discharge to the river.

EntityName name of the irrigation entity served by the wastewater treatment plant.

WWDiv volume of wastewater discharged during the month, in cubic meters.

Source

Idaho Department of Water Resources and U.S. Geological Survey, accessed on August 11, 2014; compiled data records from the U.S. Environmental Protection Agency for plants that discharge to the river, and from records of the Idaho Department of Environmental Quality for plants that discharge to land application.

Examples

```
str(div.ww)
```

---

drains   *Drain Boundaries at Stanton Crossing and Silver Creek*

Description

Polygons used to define the locations of drain boundaries in the model domain. The polygons clip the line segments along the aquifer boundary (see `alluvium.extent`), and model cells intersecting these clipped-line segments are defined as boundary cells.

Usage

```
drains
```

B12 Groundwater-Flow Model for the Wood River Valley Aquifer System, South-Central Idaho

Format

An object of SpatialPolygonsDataFrame class containing a set of 2 Polygons and a data.frame with the following variable:

Name identifier for the polygon.

cond drain conductance in square meters per day.

elev drain threshold elevation in meters above the North American Vertical Datum of 1988 (NAVD 88).

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

U.S. Geological Survey, accessed on March 27, 2015; a Keyhole Markup Language (KML) file created in Google Earth with polygons drawn by hand in areas of known drains.

Examples

```
str(drains)

sp::plot(drains, border = "red")
sp::plot(alluvium.extent, add = TRUE)
```

---

drybed   *Dry River Bed and Stream Fed Creek Conditions*

Description

A summary of dry river bed and stream fed conditions in the Wood River Valley, Idaho. Stream reaches on the Big Wood River between Glendale and Wood River Ranch are episodically dry; these dry periods are specified for calendar months when water diversions to the Bypass Canal begins before the 16th of the month and ends after the 15th of the month.

Usage

```
drybed
```

Format

An object of data.frame class with 12 records and the following variables:

Reach stream reach name

199501,…,201012 logical values indicating whether the stream reach exhibits dry-bed conditions during a stress period.

Source

Idaho Department of Water Resources, accessed on January 6, 2016; compiled from Water District 37 records.

Examples

```
str(drybed)
```

---

efficiency   *Irrigation Efficiency*

Description

The irrigation efficiency of irrigation entities in the Wood River Valley, Idaho.

Usage

    efficiency

Format

An object of data.frame class with 88 records and the following variables:

EntityName name of the irrigation entity which the irrigation efficiency is applied.

Eff estimated irrigation efficiency, the ratio of the amount of water consumed by the crop to the amount of water supplied through irrigation.

Comment brief comment on irrigation conditions.

Source

Idaho Department of Water Resources, accessed on July 9, 2015

Examples

    str(efficiency)

---

entity.components   *Irrigation Entity Components*

Description

Irrigation entities and their components in the Wood River Valley and surrounding areas. An irrigation entity is defined as an area served by a group of surface-water and/or groundwater diversion(s).

Usage

    entity.components

Format

An object of list class with components of SpatialPolygonsDataFrame-class. There are a total of 192 components, one for each month in the 1995–2010 time period. Linked data.frame objects have the following variables:

EntitySrce concatenation of the `EntityName` and `Source` character strings.

mean.et mean evapotranspiration (ET) on irrigated and semi-irrigated lands in meters.

area area of irrigated and semi-irrigated lands in square meters.

PrecipZone name of the precipitation zone; see `precip.zones` dataset for details.

et.vol volume of ET on irrigated and semi-irrigated lands in cubic meters.

precip.vol volume of precipitation on irrigated and semi-irrigated lands in cubic meters.

cir.vol volume of crop irrigation requirement in cubic meters (ET minus precipitation).

EntityName name of the irrigation entity.

Source water source, either "Mixed" for a mixture of surface water and groundwater, "SW Only" for surface water only, or "GW Only" for groundwater only.

B14   Groundwater-Flow Model for the Wood River Valley Aquifer System, South-Central Idaho

Source

Calculated from the `irr.entities`, `wetlands`, `public.parcels`, `irr.lands.year`, `et`, and `precipitation` datasets; see the 'package-datasets' vignette for the R code used in this calculation.

Examples

```
names(entity.components)
sp::plot(entity.components[["199506"]])
print(entity.components[["199506"]])
```

---

et   *Evapotranspiration*

Description

Evapotranspiration (ET) in the Wood River Valley and surrounding areas. Defined as the amount of water lost to the atmosphere via direct evaporation, transpiration by vegetation, or sublimation from snow covered areas.

Usage

```
et
```

Format

An object of RasterStack class containing 192 RasterLayer objects, one layer for each month in the 1995-2010 time period. Each cell on a layers surface grid represents the monthly depth of ET in meters. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources, accessed on November 17, 2014

See Also

et.method

Examples

```
sp::plot(et[["199505"]])
print(et)
```

| et.method | *Method Used to Calculate Evapotranspiration* |

Description

Methods used to estimate monthly distributions of evapotranspiration (ET) rate.

Usage

    et.method

Format

An object of data.frame class with 122 records with the following variables:

YearMonth year and month during which the method was applied, with a required date format of YYYYMM.

ETMethod Identifier that indicates the method used to estimate ET values. Identifiers include either "Allen-Robison", the Allen and Robison method (Allen and Robison, 2007); "METRIC", the Mapping Evapotranspiration at high Resolution and with Internalized Calibration (METRIC) model (Allen and others, 2010a); "NDVI", the Normalized Difference Vegetation Index (NDVI) method (Allen and others, 2010b); "Interpolation", interpolation from known ET data; or "METRIC-NDVI", a combination of METRIC and NDVI methods.

Source

Idaho Department of Water Resources, accessed on April 27, 2015

References

Allen, R., and Robison, C.W., 2007, Evapotranspiration and consumptive water requirements for Idaho, University of Idaho, Kimberly, Idaho.

Allen, R., Tasumi, M., Trezza, R., and Kjaersgaard, J., 2010a, METRIC mapping evapotranspiration at high resolution applications manual for Landsat satellite imagery version 2.07, University of Idaho, Kimberly, ID.

Allen, R., Robison, C.W., Garcia, M., Trezza, R., Tasumi, M., and Kjaersgaard, J., 2010b, ETrF vs NDVI relationships for southern Idaho for rapid estimation of evapotranspiration, University of Idaho, Kimberly, ID.

ET Idaho: http://data.kimberly.uidaho.edu/ETIdaho/

Examples

    str(et.method)

| gage.disch | *Daily Mean Discharge at Streamgages* |

Description

The daily mean discharge at streamgages in the Big Wood River Valley, Idaho. Discharge records bracket the 1992-2014 time period and are based on records with quality assurance code of approved ('A').

Usage

    gage.disch

Format

An object of data.frame class with 8,315 records and the following variables:

Date date during which discharge was averaged.

13135500 daily mean discharge in cubic meters per day, recorded at the USGS 13135500 Big Wood River near Ketchum streamgage.

13139510 daily mean discharge in cubic meters per day, recorded at the USGS 13139510 Big Wood River at Hailey streamgage.

13140800 daily mean discharge in cubic meters per day, recorded at the USGS 13140800 Big Wood River at Stanton Crossing near Bellevue streamgage.

Source

National Water Information System (NWIS), accessed on January 8, 2015

Examples

```
str(gage.disch)

col <- c("red", "blue", "green")
ylab <- paste("Discharge in cubic", c("meters per day", "acre-foot per year"))
inlmisc::PlotGraph(gage.disch, ylab = ylab, col = col, lty = 1:3,
                   conversion.factor = 0.29611)
leg <- sprintf("USGS \%s", names(gage.disch)[-1])
legend("topright", leg, col = col, lty = 1:3, inset = 0.02, cex = 0.7,
       box.lty = 1, bg = "#FFFFFFE7")

graphics.off()
```

---

gage.height   *Daily Mean Gage Height at Streamgages*

Description

The daily mean gage height at streamgages in the Big Wood River Valley, Idaho. Gage height records bracket the 1987-2014 and are based on records with quality assurance codes of working ('W'), in review ('R'), and approved ('A').

Usage

```
gage.height
```

Format

An object of data.frame class with 9,980 records and the following variables:

Date date during which gage height was averaged.

13135500 daily mean gage height in meters, recorded at the USGS 13135500 Big Wood River near Ketchum streamgage.

13139510 daily mean gage height in meters, recorded at the USGS 13139510 Big Wood River at Hailey streamgage.

13140800 daily mean gage height in meters, recorded at the USGS 13140800 Big Wood River at Stanton Crossing near Bellevue streamgages.

Source

Data queried from the National Water Information System (NWIS) database on December 15, 2014, by Ross Dickinson (USGS). Records recorded on May 26-28, 1991 and March 15-22, 1995 were reassigned quality assurance codes of 'I' because of assumed ice build-up. Missing data at the Big Wood River near Ketchum gage was estimated using a linear regression model based on recorded gage-height data at the Big Wood River at Hailey and Near Ketchum streamgages. Missing data at the Stanton Crossing near Bellevue gage was replaced with average gage-height values recorded at this gage.

Examples

```
str(gage.height)

col <- c("red", "blue", "green")
ylab <- paste("Gage height in", c("meters", "feet"))
inlmisc::PlotGraph(gage.height, ylab = ylab, col = col, lty = 1:3,
                   conversion.factor = 3.28084)
leg <- sprintf("USGS \%s", names(gage.height)[-1])
legend("topright", leg, col = col, lty = 1:3, inset = 0.02, cex = 0.7,
       box.lty = 1, bg = "#FFFFFFE7")

graphics.off()
```

GetSeasonalMult   *Get Seasonal Multiplier*

Description

This function determines the seasonal fraction of the long-term mean value.

Usage

```
GetSeasonalMult(x, reduction, d.in.mv.ave, fixed.dates)
```

Arguments

x	data.frame. Time series data (observations) with components of class Date and numeric.
reduction	numeric. Signal amplitude reduction, a dimensionless quantity. Its magnitude should be greater than or equal to 1; where a value of 1 indicates no reduction in the signal amplitude.
d.in.mv.ave	numeric. Number of days in the moving average subset.
fixed.dates	Date. Vector of equally spaced dates, these are the fixed locations where the moving average is calculated. The final date is neglected.

Details

A simple moving average is first calculated at dates specified in fixed.dates using past observational data in x (such as the previous 9-months of stage data recorded at a streamgage). The seasonal average of the moving average is then passed through a signal amplitude reduction algorithm. The reduced values are then divided by the mean of the seasonal reduced data to give the seasonal fraction of the mean (also known as the seasonal scaling index).

Value

Returns an object of class data.frame with the following variables:

names(x)[1] start date for each season in fixed.dates.

multiplier seasonal scaling index

Author(s)

J.C. Fisher, U.S. Geological Survey, Idaho Water Science Center

A.H. Wylie and J. Sukow, Idaho Department of Water Resources

Examples

```
obs <- dataRetrieval::readNWISdata(sites = "13139510", parameterCd = "00060",
                                   startDate = "1992-01-01", endDate = "2011-01-01")
obs <- obs[, c("dateTime", "X_00060_00003")]
obs[, 1] <- as.Date(obs[, 1])

fixed.dates <- seq(as.Date("1995-01-01"), as.Date("2011-01-01"), "1 month")
d <- GetSeasonalMult(obs, 2, 273.932, fixed.dates)
str(d)
```

GetWellConfig   *Get Well Completion and Pumping Rate in Model Space*

Description

This function determines well completions and pumping rates in model space. The pumping rate is specified for each model cell intersecting a well's open interval(s) and calculated by multiplying the estimated pumping demand by the cell's transmissivity fraction. The transmissivity fraction is calculated by dividing the cell's aquifer transmissivity by the sum of all transmissivity values for cells belonging to the same well. The transmissivity fraction calculation assumes saturated conditions in the model cell.

Usage

```
GetWellConfig(rs.model, wells, well.col, rate.col = NULL,
  lay2.hk.tol = 0.01)
```

Arguments

rs.model	RasterStack. Composed of raster layers describing the model grid and hydraulic conductivity distribution: lay1.top, lay1.bot, lay2.bot, lay3.bot, lay1.hk, lay2.hk, and lay3.hk.
wells	SpatialPointsDataFrame. Average pumping rate for each well during various times.
well.col	character. Column name of the well identifier field.
rate.col	character. Vector of column names for the pumping rate fields.
lay2.hk.tol	numeric. Hydraulic conductivity tolerance for model cells in layer 2. Used to prevent pumping in the aquitard layer of the aquifer system. Pumping is prohibited in model layer 2 cells with hydraulic conductivity values less than lay2.hk.tol and a well opening isolated to layer 2; for these cases, pumping is allocated to the adjacent layer 1 cell.

Value

Returns an object of class data.frame with the following components:

... unique identifier assigned to a well, its name is specified by well.col.

lay,row,col layer, row, and column number of a model cell, respectively.

hk hydraulic conductivity of the model cell, in meters per day.

thk vertical length of the well opening (open borehole or screen) in the model cell, in meters. A value of zero indicates that the well opening is unknown or below the modeled bedrock surface.

frac transmissivity fraction for a model cell, where transmissivity is defined as hk multiplied by thk.

... pumping rate allocated to the model cell for each time period specified by rate.col, in cubic meters per day. The pumping rate is calculated by multiplying the pumping demand for a well (specified in wells) by frac.

Author(s)

J.C. Fisher, U.S. Geological Survey, Idaho Water Science Center

A.H. Wylie, Idaho Department of Water Resources

Examples

```
## Not run: # see Appendix D. Uncalibrated Groundwater-Flow Model
```

`hill.shading`	*Land Surface Hill Shading*

Description

Hill shading of the Wood River Valley and surrounding area.

Usage

```
hill.shading
```

Format

An object of `RasterLayer` class. Each cell on the surface grid represents the hill shade. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM). The spatial grid is composed of 3,108 rows and 2,360 columns, and has cell sizes that are constant at 20 meters by 20 meters.

Source

Calculated from the slope and aspect of the `land.surface` dataset using the `terrain` and `hillShade` functions; see the appendix C. Package Dataset Creation for the R code used in this calculation.

Examples

```
raster::image(hill.shading, length(hill.shading), col = grey(0:255 / 255), asp = 1,
              axes = FALSE, xlab = "", ylab = "")
```

`idaho`	*U.S. State of Idaho*

Description

Boundary of Idaho, a state in the northwestern region of the United States.

Usage

```
idaho
```

Format

An object of SpatialPolygons class containing 1 Polygons. Cartographic boundary at 5m (1:5,000,000) resolution. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

B20 Groundwater-Flow Model for the Wood River Valley Aquifer System, South-Central Idaho

Source

U.S. Department of Commerce, U.S. Census Bureau, Geography Division/Cartographic Products Branch. A simplified representation of the State of Idaho from the 2014 Census Bureau's MAF/TIGER geographic database.

Examples

```
sp::plot(idaho, col = "#EAE2CF", border = "#BFA76F", lwd = 0.5)
print(idaho)
```

`irr.entities`   *Irrigation Entities*

Description

Delineation of areas served by a group of surface-water and (or) groundwater diversions.

Usage

```
irr.entities
```

Format

An object of SpatialPolygonsDataFrame class containing 235 Polygons and a data.frame with the following variables:

EntityName name of the irrigation entity served by a group of diversions.

Source water source, either "Mixed" for a mixture of surface water and groundwater, "SW Only" for surface-water only, or "GW Only" for groundwater only.

EntitySrce concatenation of the `EntityName` and `Source` character strings.

PrecipZone name of the precipitation zone. See `precip.zones` dataset for details.

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources (IDWR), accessed on December 11, 2014; derived from IDWR water rights database, Blaine County tax lot data, and IDWR irrigated land classification files.

Examples

```
sp::plot(irr.entities)
print(irr.entities)
```

`irr.lands`	*Irrigated Lands*

Description

Classification of irrigated lands in the Wood River Valley and surrounding areas; available for years 1996, 2000, 2002, 2006, 2008, 2009, and 2010.

Usage

```
irr.lands
```

Format

An object of list class with 7 SpatialPolygonsDataFrame components. The data.frame associated with each SpatialPolygons object has the following variable:

Status status of land during the year reviewed, either "irrigated", "semi-irrigated", or "non-irrigated".

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources, accessed on November 17, 2014; polygons derived from U.S. Department of Agriculture Common Land Unit polygons with some refinement of polygons. Irrigation status interpreted using satellite imagery and aerial photography.

See Also

irr.lands.year

Examples

```
sp::spplot(irr.lands[["2010"]], "Status")
print(irr.lands)
```

`irr.lands.year`	*Irrigation Lands for a Given Year*

Description

Annual land classification for irrigation practices is only available for select years. For missing years, this dataset provides substitute years when land-classification was available (see irr.lands).

Usage

```
irr.lands.year
```

Format

An object of data.frame class with 16 records and the following variables:

Year year with a required date format of YYYY.

IL_Year substitute year with a required date format of YYYY.

Source

Idaho Department of Water Resources, accessed on April 25, 2014

Examples

```
str(irr.lands.year)
```

---

kriging.zones   *Kriging Zones*

Description

Location of kriging zones in the Wood River Valley, used in parameter estimation.

Usage

```
kriging.zones
```

Format

An object of SpatialPolygonsDataFrame class containing 18 Polygons and a data.frame with the following variables:

Zone kriging zone, interpolation in this zone is based on the parameter values of pilot points located within this zone.

Layer model layer

Name local name

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources, accessed on June 11, 2015

See Also

pilot.points

Examples

```
sp::plot(kriging.zones)
str(kriging.zones@data)
```

`lakes`   *Lakes and Reservoirs*

Description

Lakes and reservoirs of the Wood River Valley and surrounding areas.

Usage

```
lakes
```

Format

An object of SpatialPolygonsDataFrame class containing 55 Polygons. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources (IDWR), accessed on April 2, 2014

Examples

```
sp::plot(lakes, col = "#CCFFFF", border = "#3399CC", lwd = 0.5)
str(lakes@data)
```

`land.surface`   *Topography of Land Surface*

Description

The Wood River Valley (WRV) is a geologic feature located in south-central Idaho. This dataset gives the topography of the land surface in the WRV and vicinity.

Usage

```
land.surface
```

Format

An object of SpatialGridDataFrame class. Each cell on the surface grid represents an elevation in meters above the North American Vertical Datum of 1988 (NAVD 88). Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM). The spatial grid is composed of 565 rows and 429 columns, and has cell sizes that are constant at 100 meters by 100 meters.

Source

The National Map (TNM) 1/3-arc-second raster (Gesch, 2007; Gesch and others, 2002), accessed on December 1, 2015. This dataset can be downloaded in a Esri ArcGRID format using the The National Map Viewer. Elevation datasets are distributed in geographic coordinates in units of decimal degrees, and in conformance with the NAD 83. Elevation values are in meters above the NAVD 88. The west, east, south, and north bounding coordinates for this dataset are -115, -114, 43, and 44 decimal degrees, respectively. Post-processing includes: (1) project the values of the elevation dataset into the `alluvium.thickness` spatial grid using bilinear interpolation, and (2) set values in cells where the elevation of the alluvium bottom is missing to NA.

References

Gesch, D.B., 2007, The National Elevation Dataset, in Maune, D., ed., Digital Elevation Model Technologies and Applications: The DEM Users Manual, 2nd Edition: Bethesda, Maryland, American Society for Photogrammetry and Remote Sensing, p. 99-118.

Gesch, D., Oimoen, M., Greenlee, S., Nelson, C., Steuck, M., and Tyler, D., 2002, The National Elevation Dataset: Photogrammetric Engineering and Remote Sensing, v. 68, no. 1, p. 5-11.

Examples

```
raster::image(land.surface)
summary(land.surface)
```

---

major.roads   *Major Roads*

Description

Major roads in the Wood River Valley and surrounding areas.

Usage

```
major.roads
```

Format

An object of SpatialLinesDataFrame class containing 475 Lines. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources (IDWR), accessed on October 20, 2015

Examples

```
sp::plot(major.roads)
str(major.roads@data)
```

---

map.labels   *Map Labels*

Description

Map labels in the Wood River Valley and surrounding areas.

Usage

```
map.labels
```

Format

An object of SpatialPointsDataFrame class containing 40 points with the following variables:

label text to be written.

cex character expansion factor

col,font color and font to be used, respectively.

srt string rotation in degrees.

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Best estimates of map label locations.

Examples

```
sp::plot(map.labels, col = "red")
lab <- cbind(map.labels@coords, map.labels@data)
for (i in seq_len(nrow(lab))) {
  text(lab$x[i], lab$y[i], labels = lab$label[i], cex = lab$cex[i],
       col = lab$col[i], font = lab$font[i], srt = lab$srt[i])
}
```

---

misc.locations   *Miscellaneous Locations*

Description

Miscellaneous locations in the Bellevue triangle area.

Usage

```
misc.locations
```

Format

An object of SpatialPointsDataFrame class containing 3 points with the following variable:

label description of point location.

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources (IDWR), accessed on December 23, 2015

Examples

```
sp::plot(misc.locations, pch = 20, col = "red")
text(misc.locations, labels = misc.locations@data$label, pos = 3, cex = 0.6)
```

`misc.seepage`	*Direct Recharge from Miscellaneous Seepage Sites*

Description

Direct recharge from miscellaneous seepage sites in the Wood River Valley, Idaho.

Usage

`misc.seepage`

Format

An object of data.frame class with 2 records and the following variables:

RechSite name of the recharge site, see `bellevue.wwtp.ponds` and `bypass.canal` datasets.

199501,…,201012 monthly volume of recharge during a stress period, in cubic meters. The variable name is specified as year and month.

Source

Idaho Department of Water Resources, accessed on January 15, 2015

Examples

`str(misc.seepage)`

`obs.wells`	*Observation Wells*

Description

Observation wells in the Wood River Valley aquifer system.

Usage

`obs.wells`

Format

An object of SpatialPointsDataFrame class containing 776 points with the following variables:

id unique well identifier used in this study.

SiteNo unique well identifier within the National Water Information System (NWIS).

SITEIDIDWR unique well identifier within the Idaho Department of Water Resources (IDWR) hydrologic database.

WELLNUMBER USGS or IDWR site name for the well.

PESTNAME unique well identifier for PEST.

METHODDRIL drilling method

TOTALDEPTH depth at which drilling stopped, in feet.

OPENINGMIN top of the screened interval, in feet.

OPENINGMAX bottom of the screened interval, in feet.

COMPLETION date on which the well drilling and construction stopped.

WCWELLID well construction well identifier.

ALTITUDE land surface elevation, in feet.

ALTMETHOD method for obtaining the land surface elevation.

XYMETHOD method of obtaining the spatial coordinates.

BASINNO basin number

COUNTYNAME Idaho county name

TWPRGE township and range the well is located in.

SITENAME local name for well.

desc description of well type.

TopOpen1 depth to the top of the first open interval in a groundwater well, in meters below land surface.

BotOpen1 depth to the bottom of the first open interval in a groundwater well, in meters below land surface.

TopOpen2 not applicable

BotOpen2 not applicable

Source

Idaho Department of Water Resources well construction database, accessed on June 29, 2015

See Also

obs.wells.head

Examples

```
sp::plot(obs.wells)
str(obs.wells@data)
```

---

obs.wells.head   *Hydraulic Heads in Observation Wells*

Description

Hydraulic-head (groundwater-level) measurements recorded in observation wells in the Wood River Valley aquifer system. Values are used as observations during the parameter estimation process.

Usage

```
obs.wells.head
```

Format

An object of class data.frame with 3,477 records and the following variables:

PESTNAME unique well identifier for PEST.

DateTime date and time when the measurement was recorded.

Head groundwater-level measurement (hydraulic head) in meters above the North American Vertical Datum of 1988 (NAVD 88).

Source

Idaho Department of Water Resources, accessed on June 26, 2015

See Also

obs.wells

Examples

```
str(obs.wells.head)
```

---

pilot.points   *Pilot Points*

Description

Location of pilot points in the model domain.

Usage

```
pilot.points
```

Format

An object of SpatialPointsDataFrame class containing 106 points with the following variables:

Layer model layer

Zone kriging-zone identifier

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources, accessed on June 11, 2015

See Also

kriging.zones

Examples

```
sp::plot(pilot.points)
str(pilot.points@data)
```

---

pod.gw   *Points of Diversion for Groundwater*

Description

Points of diversion for groundwater within the Wood River Valley model study area.

Usage

```
pod.gw
```

Format

An object of class data.frame with 1,755 records and the following variables:

WMISNumber unique number assigned to a water right point of diversion.

WaterRight number identifying a specific authorization to use water in a prescribed manner.

EntityName name of the irrigation entity the point of diversion is assigned to.

EntitySrce source of water for an irrigation entity. Possible sources of water include surface water, groundwater and mixed. Mixed source entities derive water from both groundwater and surface water.

Pdate priority date, the date the water right was established.

IrrRate irrigation rate in cubic meters per day, the maximum permitted water use rate associated with a water right.

Source

Idaho Department of Water Resources water rights database, accessed on December 11, 2014

See Also

pod.wells

Examples

```
summary(pod.gw)
```

---

pod.wells   *Well Completions*

Description

Well completions for pumping wells in the Wood River Valley aquifer system.

Usage

```
pod.wells
```

Format

An object of SpatialPointsDataFrame class containing 1,243 points with the following variables:

WMISNumber is a unique number assigned to a water right point of diversion.

WellUse permitted use(s) for a groundwater well.

TopOpen1 depth to the top of the first open interval in a groundwater well, in meters below land surface.

BotOpen1 depth to the bottom of the first open interval in a groundwater well, in meters below land surface.

TopOpen2 depth to the top of the second open interval in a groundwater well, in meters below land surface.

BotOpen2 depth to the bottom of the second open interval in a groundwater well, in meters below land surface.

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources water rights database, accessed on November 29, 2014

See Also

pod.gw

Examples

```
sp::plot(pod.wells)
str(pod.wells@data)
```

---

precip.zones   *Precipitation Zones*

Description

Precipitation zones specified for the Wood River Valley and surrounding areas. There are three precipitation zones, each containing a single weather station. Precipitation zones were distributed to maintain the geographic similarity between weather stations and zones.

Usage

```
precip.zones
```

Format

An object of SpatialPolygonsDataFrame class containing 3 Polygons and a data.frame with the following variables:

ID numeric identifier assigned to the polygon.

PrecipZone name of the precipitation zone: "Ketchum", the northernmost zone with data from the Ketchum National Weather Service coop weather station. "Hailey", central zone with data from the Hailey 3NNW National Weather Service coop weather station. "Picabo", southernmost zone with data from the Picabo AgriMet weather station.

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Created using the northing midpoint between weather stations, see weather.stations dataset.

See Also

precipitation

Examples

```
col <- c("#D1F2A5", "#FFC48C", "#F56991")
sp::plot(precip.zones, col = col)
legend("topright", legend = precip.zones@data$PrecipZone, fill = col, bty = "n")
sp::plot(alluvium.extent, add = TRUE)

print(precip.zones)
```

---

precipitation   *Precipitation Rate*

Description

Precipitation rates in the Wood River Valley and surrounding areas.

Usage

```
precipitation
```

Format

An object of data.frame class with 582 records and the following variables: with the following variables:

YearMonth year and month during which precipitation were recorded, with a required date format of YYYYMM.

PrecipZone name of the precipitation zone, see precip.zones dataset for details.

Precip monthly depth of precipitation accounting for spring melt, in meters.

Precip.raw monthly depth of precipitation recorded at the weather station, in meters.

Source

Idaho Department of Water Resources, accessed on April 24, 2015

References

National Oceanic and Atmospheric Administration's National Weather Service (NWS) Cooperative Observer Program

U.S. Bureau of Reclamation's Cooperative Agricultural Weather Network (AgriMet)

See Also

precip.zones, swe

Examples

```
str(precipitation)

d <- precipitation
d <- data.frame(Date = as.Date(paste0(d$YearMonth, "15"), format = "\%Y\%m\%d"),
                Precip = d$Precip)
zones <- c("Hailey", "Ketchum", "Picabo")
d1 <- d[precipitation$PrecipZone == zones[1], ]
d2 <- d[precipitation$PrecipZone == zones[2], ]
```

```
d3 <- d[precipitation$PrecipZone == zones[3], ]
d <- merge(merge(d1, d2, by = "Date"), d3, by = "Date")

col <- c("red", "blue", "green")
ylab <- paste("Precipitation in", c("meters", "feet"))
inlmisc::PlotGraph(d, ylab = ylab, col = col, lty = 1:3, conversion.factor = 3.28084)
legend("topright", zones, col = col, lty = 1:3, inset = 0.02, cex = 0.7,
       box.lty = 1, bg = "#FFFFFFE7")

graphics.off()
```

---

priority.cuts	*Priority Cuts*

Description

Priority cut dates applied to Big Wood River above Magic Reservoir and Silver Creek by Water District 37 and 37M at the end of each month.

Usage

```
priority.cuts
```

Format

An object of data.frame class with 112 records and the following variables:

YearMonth year and month during of the priority cut date, with a required date format of YYYYMM.

Pdate_BWR date of the priority cut applied to Big Wood River above Magic Reservoir by Water District 37.

Pdate_SC date of the priority cut applied to Silver Creek by Water District 37M.

Source

Idaho Department of Water Resources, accessed on November 17, 2014; compiled priority cut dates in effect at the end of each month, derived from Water District 37 and 37M records.

Examples

```
str(priority.cuts)
```

---

public.parcels	*Public Land Parcels*

Description

Non-irrigated public land parcels in the Wood River Valley and surrounding areas.

Usage

```
public.parcels
```

Format

An object of SpatialPolygons class containing 669 Polygons. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources, accessed on November 29, 2014; derived from Blaine County tax lots and aerial photography.

Examples

```
sp::plot(public.parcels)
print(public.parcels)
```

---

r.canals   *Rasterized Canals*

Description

Canal systems of the Wood River Valley and surrounding areas transferred to raster cells.

Usage

```
r.canals
```

Format

An object of RasterLayer class with indexed cell values linked to a raster attribute table (RAT). The RAT is a `data.frame` with the following components:

ID cell index

COUNT frequency of the cell index in the raster grid.

EntityName name of the irrigation entity served by the canal system.

Source

Calculated by transferring the canals dataset to grid cells in the land.surface dataset using the `rasterize` function; see the appendix C. Package Dataset Creation for the R code used in this calculation.

Examples

```
sp::plot(r.canals)
print(levels(r.canals)[[1]])
```

---

reach.recharge   *Stream-Aquifer Flow Exchange Along River Reaches*

Description

Stream-aquifer flow exchange along river reaches specified as aquifer recharge. Values used as observations in parameter estimation.

Usage

reach.recharge

Format

An object of data.frame class with 192 records and the following variables:

YearMonth year and month of the measurement record, with a required date format of YYYYMM.

nKet_Hai stream-aquifer flow exchange in the Big Wood River, near Ketchum to Hailey river reach, in cubic meters per day.

Hai_StC stream-aquifer flow exchange in the Big Wood River, Hailey to Stanton Crossing river reach, in cubic meters per day.

WillowCr stream-aquifer flow exchange in the Willow Creek river reach, in cubic meters per day.

SilverAbv stream-aquifer flow exchange in Silver Creek, above Sportsman Access river reach, in cubic meters per day.

SilverBlw stream-aquifer flow exchange in Silver Creek, Sportsman Access to near Picabo river reach, in cubic meters per day.

Details

A positive stream-aquifer flow exchange indicates aquifer recharge (a losing river reach).

Source

Calculated from continuous stream flow measurements, diversion data, return flow data, and exchange well data using a flow difference method to estimate groundwater inflows and outflows along a river reach, accessed on September 1, 2015. Derived from U.S. Geological Survey, Idaho Power Company, and Water District 37 and 37M records.

Examples

str(reach.recharge)

---

river.reaches   *Major River Reaches*

Description

Major river reaches of the Wood River Valley, Idaho.

Usage

river.reaches

Format

An object of SpatialLinesDataFrame class containing 22 Lines and a data.frame with the following variables:

Reach name of the subreaches measured in U.S. Geological Survey (USGS) seepage survey.

BigReach name of the reaches for which time series targets are available for part or all of the calibration period.

DrainRiver model boundary assignment, either "drain" or "river".

RchAvg estimated average reach gain in cubic meters per day for 1995-2010 based on a combination of gage data and the USGS seepage survey.

BigRAv estimated average reach gain in cubic meters per day for 1995-2010 based on gage data.

ReachNo reach number identifier.

Depth estimated average depth in meters of water in reach, measured from the air-water interface to the top of the riverbed sediments.

BedThk estimated thickness in meters of the saturated riverbed sediments.

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources, accessed on June 6, 2015

Examples

```
sp::plot(river.reaches)
str(river.reaches@data)
```

---

rs.entities   *Rasterized Monthly Irrigation Entities*

Description

Irrigation entities of the Wood River Valley and surrounding areas transferred to raster cells.

Usage

```
rs.entities
```

Format

An object of RasterStack class containing a 192 RasterLayer objects, one layer for each month in the 1995-2010 time period. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM). For each raster layer, indexed cell values are linked to a raster attribute table (RAT). The RAT is an object of data.frame class with the following components:

ID cell index

COUNT frequency of the cell index in the raster grid.

EntityName name of the irrigation entity served by a group of diversions.

Source

Calculated by transferring the `entity.components` dataset to grid cells in the `land.surface` dataset using the rasterize function; see the appendix C. Package Dataset Creation for the R code used in this calculation.

Examples

```
names(rs.entities)
sp::plot(rs.entities[["199507"]])
print(levels(rs.entities[["199507"]])[[1]])
```

---

rs.rech.non.irr	*Rasterized Monthly Recharge on Non-Irrigated Lands*

Description

Aerial recharge and discharge on non-irrigated lands of the Wood River Valley and surrounding areas transferred to raster cells.

Usage

```
rs.rech.non.irr
```

Format

An object of RasterStack class containing 192 RasterLayer objects, one layer for each month in the 1995-2010 time period. Each cell on a layers surface grid represents the monthly recharge in meters. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Calculated from the et, precipitation, precip.zones, and soils datasets; see the appendix C. Package Dataset Creation for the R code used in this calculation.

Examples

```
names(rs.rech.non.irr)
sp::plot(rs.rech.non.irr[["199507"]])
```

RunWaterBalance	*Run Water Balance*

Description

This function estimates natural and incidental groundwater recharge at the water table, and pumping demand at production wells. A water-balance approach is used to calculate these volumetric flow rate estimates, where positive values are flow into the aqufer system (groundwater recharge), and negative values are flow out of the system (groundwater discharge).

Usage

```
RunWaterBalance(r.grid, tr.stress.periods, ss.stress.periods = NULL,
  canal.seep = wrv::canal.seep, comb.sw.irr = wrv::comb.sw.irr,
  div.gw = wrv::div.gw, div.sw = wrv::div.sw, div.ww = wrv::div.ww,
  efficiency = wrv::efficiency, entity.components = wrv::entity.components,
  et = wrv::et, irr.entities = wrv::irr.entities,
  land.surface = wrv::land.surface, pod.gw = wrv::pod.gw,
  priority.cuts = wrv::priority.cuts, r.canals = wrv::r.canals,
  rs.entities = wrv::rs.entities, rs.rech.non.irr = wrv::rs.rech.non.irr,
  verbose = FALSE)
```

Arguments

r.grid   RasterLayer. Gridded numeric values where NA indicates an 'inactive' cell in the top model layer.

tr.stress.periods
                Date. Vector of start and end dates for each stress period in the simulation.

ss.stress.periods
                Date. Vector of start and end dates for stress periods used to create steady-state conditions.

canal.seep   data.frame. See canal.seep dataset for details.

comb.sw.irr   data.frame. See comb.sw.irr dataset for details.

div.gw   data.frame. See div.gw dataset for details.

div.sw   data.frame. See div.sw dataset for details.

div.ww   data.frame. See div.gw dataset for details.

efficiency   data.frame. See efficiency dataset for details.

entity.components
                list. See entity.components dataset for details.

et   RasterStack. See et dataset for details.

irr.entities   SpatialPolygonsDataFrame. See irr.entities dataset for details.

land.surface   RasterLayer. See land.surface dataset for details.

pod.gw   data.frame. See pod.gw dataset for details.

priority.cuts   data.frame. See priority.cuts dataset for details.

r.canals   RasterLayer. See r.canals dataset for details.

rs.entities   RasterStack. See rs.entities dataset for details.

rs.rech.non.irr
                RasterStack. See rs.rech.non.irr dataset for details.

verbose   logical. Indicates whether to return summary tables: natural.rech, inciden.rech, and pumping.rech.

Value

Returns an object of class list with the following components:

(1) Water-table flow data (combines natural and incidental groundwater recharge) are stored in areal.rech, an object of RasterStack class with raster layers for each model stress period; cell values are specified as volumetric flow rates in cubic meters per day.

(2) Production well pumping data are stored in pod.rech, an object of data.frame class with the following components:

WMISNumber unique number assigned to a water right point of diversion.

ss,199501,…,201012 volumetric flow rate, specified for each stress period, in cubic meters per day.

(3) Natural groundwater recharge data are stored in natural.rech, an object of data.frame class with the following components:

YearMonth calendar year and month YYYYMM.

Area land-surface area of non-irrigated lands, in square meters.

ET evapotranspiration on non-irrigated lands, in cubic meters per month.

Rech volumetric flow rate, in cubic meters per month.

(4) Incidental groundwater recharge data are stored in inciden.rech, an object of data.frame class with the following components:

EntityName name of the irrigation entity.

YearMonth calendar year and month YYYYMM.

SWDiv surface-water diversions, in cubic meters per month.

SeepFrac canal seepage as a fraction of diversions, a dimensionless quantity.

CanalSeep canal seepage, in cubic meters per month.

SWDel surface-water delivered to field headgates, in cubic meters per month.

area.sw area irrigated by only surface water, in square meters.

et.sw evapotranspiration on lands irrigated by only surface water, in cubic meters per month.

precip.sw precipitation on lands irrigated by only surface water, in cubic meters per month.

cir.sw crop irrigation requirement on lands irrigated by only surface water, in cubic meters per month.

area.mix area irrigated by both surface and groundwater, in square meters.

et.mix evapotranspiration on lands irrigated by both surface and groundwater, in cubic meters per month.

precip.mix precipitation on lands irrigated by both surface and groundwater, in cubic meters per month.

cir.mix crop irrigation requirement on lands irrigated by both surface and groundwater, in cubic meters per month.

area.gw area irrigated by only groundwater, in square meters.

et.gw evapotranspiration on lands irrigated by only groundwater, in cubic meters per month.

precip.gw precipitation on lands irrigated by only groundwater, in cubic meters per month.

cir.gw crop irrigation requirement on lands irrigated by only groundwater, in cubic meters per month.

Eff irrigation efficiency, a dimensionless quantity.

GWDiv recorded groundwater diversions, in cubic meters per month.

WWDiv inflow to municipal wastewater treatment plants, in cubic meters per month.

hg.sw surface-water delivered to field headgates on lands irrigated by only surface water, in cubic meters per month.

hg.mix surface-water delivered to field headgates on lands irrigation by both surface and groundwater, in cubic meters per month.

rech.sw incidental groundwater recharge beneath lands irrigated by only surface water, in cubic meters per month.

gw.dem.mix groundwater demand on lands irrigated by both surface and groundwater, in cubic meters per month.

gw.div.est calculated groundwater diversions, in cubic meters per month.

rech.mix incidental groundwater recharge beneath lands irrigated by both surface and groundwater, in cubic meters per month.

gw.only groundwater demand on lands irrigated by only groundwater in entities with lands also irrigated by both surface and groundwater, in cubic meters per month.

rech.muni incidental groundwater recharge beneath entities with lands irrigated by only groundwater and lands irrigated by both surface and groundwater, in cubic meters per month.

gw.dem.gw groundwater demand on lands irrigated by only groundwater in entities without surface-water irrigation, in cubic meters per month.

rech.gw incidental groundwater recharge beneath lands irrigated by only groundwater, in cubic meters per month.

area.model area of the irrigation entity that is located in the model domain, in square meters.

Volumetric flow rates are calculated for their respective area in the irrigation entity—not just that part overlying the model area. Flow rate values are given this way in order to facilitate with quality assurance of the water-budget calculation. To calculate a simulated volumetric-flow rate: divide the flow rate by the affected area, and then multiply this value by the area of the irrigation entity that is located in the model domain (`area.model`).

(5) Well pumping data are also stored in `pumping.rech` (see `pod.rech` component), an object of data.frame class with the following components:

WMISNumber unique number assigned to a water right point of diversion.

YearMonth calendar year and month YYYYMM.

Pumping volumetric rate of pumping, in cubic meters per month.

Author(s)

J.C. Fisher, U.S. Geological Survey, Idaho Water Science Center

J. Sukow and M. McVay, Idaho Department of Water Resources

See Also

UpdateWaterBudget

Examples

```
## Not run: # see Appendix A. Package Introduction
```

---

seepage.study   *Stream Seepage Study*

Description

A Wood River Valley stream seepage study with streamflow measurements made during the months of August 2012, October 2012, and March 2013.

Usage

```
seepage.study
```

Format

An object of SpatialPointsDataFrame class containing 82 points with the following variables:

Order index used to preserve the downstream order of measurement sites.

Name local name for the measurement site.

SiteNo unique identifier for the measurement site within the National Water Information System (NWIS).

Type the type of measurement site: "Big Wood River", "Willow Creek", "Spring fed creeks", "Silver Creek", "Diversion", "Exchange well inflow", "Return", and "Tributary".

Comments abbreviated site name

Aug volumetric flow rate measured during August 2012, in cubic meters per day.

Oct volumetric flow rate measured during October 2012, in cubic meters per day.

Mar volumetric flow rate measured during March 2013, in cubic meters per day.

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Derived from Bartolino (2014) seepage study, Idaho Department of Water Resources, Water District 37 and 37M flow records.

References

Bartolino, J.R., 2014, Stream seepage and groundwater levels, Wood River Valley, south-central Idaho, 2012–13: U.S. Geological Survey Scientific Investigations Report 2014-5151, 34 p., https://dx.doi.org/10.3133/sir20145151.

Examples

```
sp::plot(seepage.study)
str(seepage.study@data)
```

---

sensitivity   *PEST Sensitivity*

Description

Calibrated parameter values and composite sensitivities generated by PEST.

Usage

    sensitivity

Format

An object of data.frame class with 336 records and the following variables:

parameter.desc parameter description

ID unique identifier within the parameter type, such as an identifier for a pilot point or irrigation entity.

units parameter units

start.value starting parameter value prior to model calibration.

lower.bound lower bound placed on the parameter value during the model-calibration process.

upper.bound upper bound placed on the parameter value during the model-calibration process.

parameter.name PEST parameter name

group PEST parameter group

value calibrated parameter value estimated by PEST.

comp.sens composite sensitivity generated during the final iteration of PEST.

rel.comp.sens relative composite sensitivity

Source

Idaho Department of Water Resources, accessed on January 15, 2016

See Also

pilot.points, irr.entities, river.reaches, drains, tributaries

Examples

    str(sensitivity)

`soils`	*Soil Units*

Description

Representation of mapped surficial soil units created by the Idaho Office of the National Resource Conservation Service (NRCS). Soils have been assigned a percolation rate based on the average, saturated hydraulic conductivity of the soils as classified using the Unified Soil Classification System (USCS).

Usage

```
soils
```

Format

An object of SpatialPolygonsDataFrame class containing 718 Polygons and a data.frame with the following variables:

GroupSymbol soil class identifier

SoilLayer identifier used to differentiate the soil data source used to create the soils map. Data sources are either 'USCS' or 'STATSGO', the NRCS State Soil Geographic Data Base.

SoilClass description of the soil class.

MinRate lower percolation rate limit for the soil class, in meters per month.

MaxRate upper percolation rate limit for the soil class, in meters per month.

PercolationRate percolation rate in meters per month.

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources, accessed on April 22, 2015

Examples

```
sp::spplot(soils, "PercolationRate")
str(soils@data)
```

`streamgages`	*Streamgages*

Description

Select streamgages in the Wood River Valley.

Usage

```
streamgages
```

Format

An object of SpatialPointsDataFrame class containing 9 points and a data.frame with the following variable:

SiteNo unique site number for the streamgage.

SiteName official name of the streamgage.

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

National Water Information System (NWIS), accessed on May 29, 2015.

Examples

```
str(streamgages)
```

---

streams.rivers   *Streams and Rivers*

Description

Streams and rivers of the Wood River Valley and surrounding areas.

Usage

```
streams.rivers
```

Format

An object of SpatialLinesDataFrame class containing 581 Lines. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources (IDWR), accessed on April 2, 2014

Examples

```
sp::plot(streams.rivers, col = "#3399CC")
str(streams.rivers@data)
```

subreach.recharge	*Stream-Aquifer Flow Exchange Along River Subreaches*

Description

Stream-aquifer flow exchange along river subreaches specified as aquifer recharge. Values used as observations in parameter estimation.

Usage

```
subreach.recharge
```

Format

An object of data.frame class with 19 records and the following variables:

ReachNo subreach number identifier

Reach name of the subreach.

BigReachNo reach number identifier

BigReach name of the reach.

Aug estimated volumetric flow rate measured during August 2012, in cubic meters per day.

Oct estimated volumetric flow rate measured during October 2012, in cubic meters per day.

Mar estimated volumetric flow rate measured during March 2013, in cubic meters per day.

Details

A positive stream-aquifer flow exchange indicates aquifer recharge (also know as a losing river subreach).

Source

Flow values calculated from `seepage.study` data.

Examples

```
str(subreach.recharge)
```

swe	*Snow Water Equivalent*

Description

Average daily snow water equivalent (SWE) at weather stations in the Wood River Valley and surrounding areas.

Usage

```
swe
```

Format

An object of data.frame class with 366 records and the following variables:

MonthDay month and day, with a required date format of `MMDD`.

Choco daily SWE recorded at the Chocolate Gulch snow telemetry (SNOTEL) weather station.

Hailey daily SWE recorded at the Hailey Ranger Station at Hailey hydrometeorological automated data system (HADS) weather station.

Picabo daily SWE recorded at the Picabo PICI HADS weather station.

Source

Idaho Department of Water Resources, accessed on April 24, 2015

See Also

weather.stations, precip.zones, precipitation

Examples

```
str(swe)
```

---

tributaries   *Tributary Basin Underflow*

Description

Location and average flow conditions for model boundaries in the major tributary canyons and upper part of the Wood River Valley, south-central Idaho.

Usage

```
tributaries
```

Format

An object of SpatialPolygonsDataFrame class containing a set of 22 Polygons and a data.frame with the following variable:

Name tributary name

MinLSD minimum land-surface datum (elevation) along the transect, in meters above the North American Vertical Datum of 1988 (NAVD 88).

BdrkDepth mean saturated thickness along the transect line, in meters; estimated as the distance between the estimated water table and bedrock elevations.

TribWidth width of the tributary canyon, or length of the transect line, in meters.

LandGrad land surface elevation gradient perpendicular to the cross-sectional transect line, a dimensionless quantity.

K hydraulic conductivity in meters per day.

SatArea estimated saturated cross-sectional area, in square meters; its geometry is represented as the lower-half of an ellipse with width and height equal to `TribWidth` and `BdrkDepth`, respectively.

DarcyFlow groundwater flow rate, in cubic meters per day, calculated using a Darcian analysis.

BasinArea land-surface area defined by the basin above the cross-sectional transect line.

BasinAreaType label that describes the relative basin size; where `"big"` indicates a basin area greater than 10 square miles (25.9 square kilometers), and `"small"` indicates a basin area that is less than this breakpoint value.

PrecipRate mean precipitation rate within the basin area, in meters per day.

PrecipFlow mean precipitation flow rate, in cubic meters per day, calculated by multiplying `PrecipRate` by `BasinArea`.

FlowRatio ratio of darcy flow rate to precipitation flow rate, or `DarcyFlow` divided by `PrecipFlow`, a dimensionless quantity.

Flow estimated average volumetric flow rate, in cubic meters per day.

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

U.S. Geological Survey, accessed on July 2, 2015; a Keyhole Markup Language (KML) file created in Google Earth with polygons drawn by hand in areas of known specified flow boundaries. Transect lines are defined by the polygon boundaries within the extent of alluvium aquifer (see `alluvium.extent` dataset). The land surface gradient (`LandGrad`) was estimated from the `land.surface` dataset. Hydraulic conductivity (`K`) is the average of two geometric means of hydraulic conductivity in the unconfined aquifer taken from table 2 in Bartolino and Adkins (2012). The U.S. Geologic Survey StreamStats tool (Ries and others, 2004) was used to delineate the basin area (`BasinArea`) and estimate the precipitation rate (`PrecipRate`). See the appendix C. Package Dataset Creation for the R code used to calculate the flow estimates (`Flow`).

References

Bartolino, J.R., and Adkins, C.B., 2012, Hydrogeologic framework of the Wood River Valley aquifer system, south-central Idaho: U.S. Geological Survey Scientific Investigations Report 2012-5053, 46 p., available at https://pubs.usgs.gov/sir/2012/5053/.

Ries, K.G., Steeves, P.A., Coles, J.D., Rea, A.H., and Stewart, D.W., 2004, StreamStats–A U.S. Geological Survey web application for stream information: U.S. Geological Survey Fact Sheet FS-2004-3115, 4 p., available at https://pubs.er.usgs.gov/publication/fs20043115.

Examples

```
sp::plot(tributaries, border = "red")
sp::plot(alluvium.extent, add = TRUE)
str(tributaries@data)
```

---

tributary.streams   *Tributary Streams*

Description

Tributary streams of the upper Wood River Valley and surrounding areas.

Usage

```
tributary.streams
```

Format

An object of SpatialLinesDataFrame class containing 88 Lines. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

Idaho Department of Water Resources, accessed on June 1, 2015

Examples

```
sp::plot(tributary.streams, col = "#3399CC")
str(tributary.streams@data)
```

UpdateWaterBudget   *Update Water Budget*

Description

This function determines the specified-flow boundary conditions for the groundwater-flow model. These boundary conditions include: (1) natural and incidental groundwater recharge at the water table, (2) groundwater pumping at production wells, and (3) groundwater underflow in the major tributary valleys. Specified-flow values are saved to disk by rewriting the MODFLOW Well Package file ('.wel'). Note that this function is executed after each iteration of PEST.

Usage

```
UpdateWaterBudget(dir.run, id, qa.tables = c("none", "si", "english"),
  ss.interval = NULL, iwelcb = ifelse(interactive(), 50L, 0L),
  canal.seep = wrv::canal.seep, efficiency = wrv::efficiency,
  gage.disch = wrv::gage.disch, pod.wells = wrv::pod.wells,
  tributaries = wrv::tributaries, ...)
```

Arguments

dir.run	character. Path name of the directory to read/write model files.
id	character. Short identifier (file name) for model files.
qa.tables	character. Indicates if quality assurance tables are written to disk; by default "none" of these tables are written. Values of "si" and "english" indicate that table values are written in metric and English units, respectively.
ss.interval	Date or character. Vector of length 2 specifying the start and end dates for the period used to represent steady-state boundary conditions. That is, recharge values for stress periods coinciding with this time period are averaged and used as steady-state boundary conditions. The required date format is YYYY-MM-DD. This argument overrides the ss.stress.periods object in the 'model.rda' file, see 'Details' section for additional information.
iwelcb	integer. A flag and unit number. If equal to zero, the default, cell-by-cell flow terms resulting from conditions in the MODFLOW Well Package will not be written to disk. A value of 0 is appropriate for model calibration, where MODFLOW run times are kept as short as possible. If greater than zero, the cell-by-cell flow terms are written to disk. See the MODFLOW Name File ('*.nam') for the unit number associated with the budget file ('*.bud'). The default value is 50 (value specified in the WriteModflowInput function) if R is being used interactively and 0 otherwise.
canal.seep	data.frame. See canal.seep dataset for details.
efficiency	data.frame. See efficiency dataset for details.
gage.disch	data.frame. See gage.disch dataset for details.
pod.wells	SpatialPointsDataFrame. See pod.wells dataset for details.
tributaries	SpatialPolygonsDataFrame. See tributaries dataset for details.
...	Arguments to be passed to RunWaterBalance, such as evapotranspiration et.

Details

Files read during execution, and located within the `dir.run` directory, inlcude the MODFLOW hydraulic conductivity reference files 'hk1.ref', 'hk2.ref', and 'hk3.ref' corresponding to model layers 1, 2, and 3, respectively. Hydraulic conductivity values are read from a two-dimensional array in matrix format with 'white-space' delimited fields. And a binary data file 'model.rda' containing the following serialized R objects: `rs`, `misc`, `trib`, `tr.stress.periods`, and `ss.stress.periods`.

`rs` is an object of RasterStack class with raster layers "lay1.top", "lay1.bot", "lay2.bot", and "lay3.bot". These raster layers describe the geometry of the model grid; that is, the upper and lower elevation of model layer 1, and the bottom elevations of model layers 2 and 3. Missing cell values (equal to NA) indicate inactive model cells lying outside of the model domain.

`misc` is a data.frame object with miscellaneous seepage, such as from the 'Bellevue Waste Water Treatment Plant ponds' and the 'Bypass Canal'. This object is comprised of the following components: **lay**, **row**, **col** are integer values specifying a model cell's layer, row, and column index, respectively; and **ss**, **199501**, **199502**, . . . , **201012** are numeric values of elevation during each stress period, respectively, in meters above the North American Vertical Datum of 1988.

`trib` is a data.frame object with default values for the long-term mean underflows in each of the tributary basins. The object is comprised of the following components: **Name** is a unique identifier for the tributary basin; **lay**, **row**, **col** are `integer` values of a model cell's layer, row, and column index, respectively; and **ss**, **199501**, **199502**, . . . , **201012** are numeric values of underflow during each stress period, respectively, in cubic meters per day.

`tr.stress.periods` is a vector of Date values giving the start and end dates for stress periods in the model simulation period (1995–2010).

`ss.stress.periods` is a vector of Date values giving the start and end dates for stress periods used to define steady-state conditions.

`reduction` is a numeric default value for the signal amplitude reduction algorithm, a dimensionless quantity.

`d.in.mv.ave` is a numeric default value for the number of days in the moving average subset.

Value

Returns an object of difftime class, the runtime for this function. Used for the side-effect of files written to disk.

A MODFLOW Well Package file '<id>.wel' is always written to disk; whereas, parameter estimation files 'seep.csv', 'eff.csv', and 'trib.csv', and a script file 'UpdateBudget.bat', are only written if they do not already exist. The script file may be used to automate the execution of this function from a file manager (such as, Windows Explorer).

The 'seep.csv' file stores as tabular data the canal seepage fraction for each of the irrigation entities. Its character and numeric data fields are delimited by commas (a comma-separated-value [CSV] file). The first line is reserved for field names "EntityName" and "SeepFrac".

The 'eff.csv' file stores as tabular data the irrigation efficiency for each of the irrigation entities. Its character and numeric data fields are delimited by commas. The first line is reserved for field names "EntityName" and "Eff".

The 'trib.csv' file stores as tabular data the underflow boundary conditions for each tributary basin. Its character and numeric data fields are delimited by commas. The first line is reserved for field names "Name" and "Value". Data records include a long-term mean flow multiplier for each of the tributary basins (name is the unique identifier for the tributary), a record for the amplitude reduction (`reduction`), and a record for the number of days in the moving average (`d.in.mv.ave`).

If the `qa.tables` argument is specified as either "si" or "english", quality assurance tables are written to disk as CSV files ('qa-*.csv'). Volumetric flow rate data within these tables is described in the 'Value' section of the [RunWaterBalance](#) function; see returned list components `natural.rech`, `inciden.rech`, and `pumping.rech`. The well configuration data are described in the 'Value' section of the [GetWellConfig](#) function.

Author(s)

J.C. Fisher, U.S. Geological Survey, Idaho Water Science Center

See Also

[RunWaterBalance](#), [GetSeasonalMult](#)

Examples

```
## Not run:
  dir.run <- file.path(getwd(), "model/model1")
  UpdateWaterBudget(dir.run, "wrv_mfusg", qa.tables = "si",
                    ss.interval = c("1998-01-01", "2011-01-01"))

## End(Not run)
```

---

weather.stations   *Weather Stations*

Description

Weather stations in the Wood River Valley and surrounding areas.

Usage

```
weather.stations
```

Format

An object of SpatialPointsDataFrame class containing 5 points and the following variables:

name name of the weather station.

id unique identifier for the weather station.

type type of weather stations: `"HADS"`, a Hydrometeorological Automated Data System operated by the National Weather Service Office of Dissemination; `"AgriMet"`, a satellite-telemetry network of automated agricultural weather stations operated and maintained by the Bureau of Reclamation; and `"SNOTEL"`, an automated system of snowpack and related climate sensors operated by the Natural Resources Conservation Service.

organization is the managing organization.

elevation is the elevation of the weather station in meters above the North American Vertical Datum of 1988 (NAVD 88).

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

National Oceanic and Atmospheric Administration (NOAA), Bureau of Reclamation, Natural Resources Conservation Service (NRCS), accessed on May 1, 2015

Examples

```
sp::plot(alluvium.extent)
sp::plot(weather.stations, col = "red", add = TRUE)
str(weather.stations@data)
```

---

wetlands   *Wetlands*

Description

Wetlands in the Wood River Valley and surrounding areas.

Usage

wetlands

Format

An object of SpatialPolygons class containing 3,024 Polygons. Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

U.S. Fish and Wildlife Service National Wetlands Inventory, accessed on April 2, 2014

Examples

```
sp::plot(wetlands, col = "#CCFFFF", border = "#3399CC", lwd = 0.5)
print(wetlands)
```

---

wl.200610   *Groundwater-Level Contours for October 2006*

Description

Groundwater-level contours with a 20 foot (6.096 meter) contour interval for the unconfined aquifer in the Wood River Valley, south-central Idaho, representing conditions during October 2006.

Usage

wl.200610

Format

An object of SpatialLinesDataFrame class containing 265 Lines and a data.frame with the following variables:

CONTOUR groundwater elevation contour value in meters above the North American Vertical Datum of 1988 (NAVD 88).

certainty certainty of the groundwater-level contour based on data position and density, specified as "good" or "poor".

Geographic coordinates are in units of meters, in conformance with the North American Datum of 1983 (NAD 83), and placed in the Idaho Transverse Mercator projection (IDTM).

Source

This dataset is from Plate 1 in Skinner and others (2007), and available on the WRD NSDI Node.

References

Skinner, K.D., Bartolino, J.R., and Tranmer, A.W., 2007, Water-resource trends and comparisons between partial development and October 2006 hydrologic conditions, Wood River Valley, south-central, Idaho: U.S. Geological Survey Scientific Investigations Report 2007-5258, 30 p., available at https://pubs.usgs.gov/sir/2007/5258/

Examples

```
is.good <- wl.200610@data$certainty == "good"
sp::plot(wl.200610[is.good, ], col = "blue")
sp::plot(wl.200610[!is.good, ], col = "red", lty = 2, add = TRUE)
str(wl.200610@data)
```

WriteModflowInput   *Write MODFLOW Input Files*

Description

This function generates and writes input files for a MODFLOW simulation of groundwater flow in the Wood River Valley (WRV) aquifer system.

Usage

```
WriteModflowInput(rs.model, rech, well, trib, misc, river, drain, id, dir.run,
  is.convertible = FALSE, ss.perlen = 0L, tr.stress.periods = NULL,
  ntime.steps = 4L, mv.flag = 1e+09, auto.flow.reduce = FALSE,
  verbose = TRUE)
```

Arguments

rs.model	RasterStack. Collection of RasterLayer objects with the same extent and resolution, see 'Details' for required raster layers.
rech	data.frame. Areal recharge rate, in cubic meters per day. Variables describe the model cell location (lay, row, col) and volumetric rate during each stress period (ss, 199501, 199502, …, 201012).
well	data.frame. Well pumping at point locations in cubic meters per day. Variables describe the model cell location and volumetric rate during each stress period.
trib	data.frame. Incoming flows from the major tributary canyons. Variables describe the model cell location and volumetric rate during each stress period.
misc	data.frame. Direct recharge from miscellaneous seepage sites in cubic meters per day. Variables describe the model cell location and volumetric rate during each stress period.
river	data.frame. River conditions. Variables describe the model cell location, river conductance (cond) in square meters per day, river bottom elevation (bottom) in meters above the North American Vertical Datum of 1988 (NAVD 88), and a numeric river reach identifier (id).
drain	data.frame. Drain conditions for groundwater outlet boundaries. Variables describe the model cell location, drain threshold elevation (elev) in meters above the NAVD 88, drain conductance (cond) in square meters per day, and a numeric identifier (id) indicating the drains general location.
id	character. Short identifier for the model run.
dir.run	character. Path name of the directory to write model input files.
is.convertible	
	logical. If true, indicates model layers are 'convertible', with transmissivity computed using upstream water-table depth. Otherwise, model layers are 'confined' and transmissivity is constant over time.
ss.perlen	integer or difftime. Length of the steady-state stress period in days.

tr.stress.periods
>   Date. Vector of start times for each stress period in the transient simulation. If missing, only steady-state conditions are simulated.

ntime.steps   integer. Number of uniform time steps in a stress period.

mv.flag   numeric. Missing value flag for output reference data files.

auto.flow.reduce
>   logical. If true, a simulated well will adjust pumping according to supply under bottom-hole conditions. Pumping rates that have been automatically reduced will be written to a model output file ('.afr').

verbose   logical. If true, additional information is written to the listing file ('.lst') and budget file ('.bud')

Details

Groundwater flow in the WRV aquifer system is simulated using the MODFLOW-USG groundwater-flow model. This numerical model was chosen for its ability to solve complex unconfined groundwater flow simulations. The solver implemented in MODFLOW-USG incorporates the Newton-Raphson formulation for improving solution convergence and avoiding problems with the drying and rewetting of cells (Niswonger and others, 2011). A structured finite-difference grid is implemented in the model to (1) simplify discretization, (2) keep formats and structures for the MODFLOW-USG packages identical to those of MODFLOW-2005, and (3) allow any MODFLOW post-processor to be used to analyze the results of the MODFLOW-USG simulation (such as Model Viewer).

Model input files are written to dir.run and include the following MODFLOW Package files: Name ('.nam'), Basic ('.ba6'), Discretization ('.dis'), Layer-Property Flow ('.lpf'), Drain ('.drn'), River ('.riv'), Well ('.wel'), Sparse Matrix Solver ('.sms'), and Output Control ('.oc'). See the users guide (*Description of Model Input and Output*) included with the MODFLOW-USG software for details on input file formats and structures.

Data within the rech, well, trib, and misc arguments are combined in the MODFLOW Well Package and identifiable with added id values of 1, 2, 3, and 4, respectively.

The Layer-Property Flow file includes options for the calculation of vertical flow in partially dewatered cells. For the WRV model, where there is no indication that perched conditions exist, CONSTANTCV and NOVFC options are used to create the most stable solution (Panday and others, 2013, p. 15-16). Options for the Sparse Matrix Solver were set for unconfined simulations by implementing an upstream-weighting scheme with Newton-Raphson linearization, Delta-Bar-Delta under-relaxation, and the χMD solver of Ibaraki (2005).

The raster stack rs.model includes the following layers:

lay1.top elevation at the top of model layer 1 (land surface), in meters above the NAVD 88.

lay1.bot elevation at the bottom of model layer 1, in meters above the NAVD 88.

lay2.bot elevation at the bottom of model layer 2.

lay3.bot elevation at the bottom of model layer 3.

lay1.strt initial (starting) hydraulic head in model layer 1, in meters above the NAVD 88.

lay2.strt initial hydraulic head in model layer 2.

lay3.strt initial hydraulic head in model layer 3.

lay1.zones hydrogeologic zones in model layer 1 where values equal to 1 is unconfined alluvium, equal to 2 is basalt, equal to 3 is clay, and equal to 4 is confined alluvium.

lay2.zones hydrogeologic zones in model layer 2.

lay3.zones hydrogeologic zones in model layer 3.

lay1.hk horizontal hydraulic conductivity in model layer 1, in meters per day.

lay2.hk horizontal hydraulic conductivity in model layer 2.

lay3.hk horizontal hydraulic conductivity in model layer 3.

Value

Used for the side-effect of files written to disk.

Author(s)

J.C. Fisher, U.S. Geological Survey, Idaho Water Science Center

References

Ibaraki, M., 2005, χMD User's guide-An efficient sparse matrix solver library, version 1.30: Columbus, Ohio State University School of Earth Sciences.

Niswonger, R.G., Panday, Sorab, and Ibaraki, Motomu, 2011, MODFLOW-NWT, A Newton formulation for MODFLOW-2005: U.S. Geological Survey Techniques and Methods 6-A37, 44 p., available at https://pubs.usgs.gov/tm/tm6a37/.

Panday, Sorab, Langevin, C.D., Niswonger, R.G., Ibaraki, Motomu, and Hughes, J.D., 2013, MODFLOW-USG version 1: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation: U.S. Geological Survey Techniques and Methods, book 6, chap. A45, 66 p., available at https://pubs.usgs.gov/tm/06/a45/.

Examples

```
## Not run: # see Appendix D. Uncalibrated Groundwater-Flow Model
```

---

zone.properties   *Hydraulic Properties of Hydrogeologic Zones*

Description

Estimates of the hydraulic properties for each hydrogeologic zone.

Usage

```
zone.properties
```

Format

An object of `data.frame` class with the following variables:

ID numeric identifier for the hydrogeologic zone.

name name of the hydrogeologic zone.

vani vertical anisotropy, a dimensionless quantity.

sc storage coefficient, a dimensionless quantity.

sy specific yield, a dimensionless quantity.

hk horizontal hydraulic conductivity in meters per day.

ss specific storage in inverse meter.

References

Bartolino, J.R., and Adkins, C.B., 2012, Hydrogeologic framework of the Wood River Valley aquifer system, south-central Idaho: U.S. Geological Survey Scientific Investigations Report 2012-5053, 46 p., available at https://pubs.usgs.gov/sir/2012/5053/.

Examples

```
str(zone.properties)
```