

# Package ‘potentiomap’

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**Title** Build Potentiometric Surfaces and Flow Arrows

**Version** 0.1.0

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**Description** Builds potentiometric surface products from groundwater monitoring data. The package prepares groundwater observations from direct water-level measurements or depth-to-water data paired with land-surface elevations, interpolates thin-plate spline surfaces by default, supports alternative and user-supplied interpolation methods, exports raster and contour products, and derives hydraulic-gradient flow arrows. Raster operations use methods from Hijmans (2025) <[doi:10.32614/CRAN.package.terra](https://doi.org/10.32614/CRAN.package.terra)>, thin-plate spline interpolation uses methods from Nychka et al. (2021) <[doi:10.5065/D6W957CT](https://doi.org/10.5065/D6W957CT)>, and geostatistical interpolation uses methods from Pebesma (2004) <[doi:10.1016/j.cageo.2004.03.012](https://doi.org/10.1016/j.cageo.2004.03.012)>.

**License** GPL-3

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|                   |   |
|-------------------|---|
| ps_arrow_vertices | <i>Extract arrow base or tip points</i> |
|-------------------|---|

---

## Description

Extract arrow base or tip points

## Usage

```
ps_arrow_vertices(arrows, which = c("last", "first"), out_file = NULL)
```

## Arguments

|          |   |
|----------|---|
| arrows   | A line SpatVector or path to a line vector file.  |
| which    | "first" for arrow bases or "last" for arrow tips. |
| out_file | Optional output vector path.                      |

## Value

A point SpatVector.

## Examples

```
data("synthetic_wells")
pts <- ps_make_points(synthetic_wells, "x", "y", "gw_elevation",
                     "well_id", "EPSG:26916")
s <- ps_interpolate(pts, methods = "IDW", grid_res = 100)
arrows <- ps_flow_arrows(s$IDW, res_factor = 4, scale = 60)
tips <- ps_arrow_vertices(arrows$arrows, which = "last")
tips
```

---

ps\_contours                      *Create contours from a surface raster*

---

**Description**

Create contours from a surface raster

**Usage**

```
ps_contours(surface, interval = 1, levels = NULL)
```

**Arguments**

|          |   |
|----------|---|
| surface  | A terra::SpatRaster potentiometric surface.                           |
| interval | Contour interval in map elevation units.                              |
| levels   | Optional explicit contour levels. When supplied, interval is ignored. |

**Value**

A line terra::SpatVector of contours.

**Examples**

```
data("synthetic_wells")
pts <- ps_make_points(synthetic_wells, "x", "y", "gw_elevation",
                     "well_id", "EPSG:26916")
s <- ps_interpolate(pts, methods = "IDW", grid_res = 100)
ctr <- ps_contours(s$IDW, interval = 1)
ctr
```

---

ps\_export\_surfaces              *Export surfaces, contours, and quicklook PNGs*

---

**Description**

Export surfaces, contours, and quicklook PNGs

**Usage**

```
ps_export_surfaces(
  surfaces,
  out_dir,
  out_stub = "gw",
  contour_interval = 1,
  points = NULL,
  write_raster = TRUE,
```

```

    write_contours = TRUE,
    write_png = TRUE
  )

```

### Arguments

surfaces            A named list of SpatRaster objects, such as the result of ps\_interpolate().

out\_dir            Output directory.

out\_stub           File prefix.

contour\_interval   Contour interval.

points            Optional observation points to draw on quicklook figures.

write\_raster, write\_contours, write\_png  
Choose which outputs to write.

### Value

A data frame listing written files.

### Examples

```

data("synthetic_wells")
pts <- ps_make_points(synthetic_wells, "x", "y", "gw_elevation",
                     "well_id", "EPSG:26916")
s <- ps_interpolate(pts, methods = "IDW", grid_res = 100)
out <- ps_export_surfaces(s, points = pts, out_dir = tempdir())
out

```

---

ps\_flow\_arrows

*Generate hydraulic-gradient flow arrows*

---

### Description

Derives slope, aspect, hydraulic gradient, and downgradient arrows from a potentiometric surface raster.

### Usage

```

ps_flow_arrows(
  surface,
  res_factor = 7,
  scale = 50,
  min_gradient = 1e-05,
  log_gradient = FALSE,
  log_arrow = FALSE,
  out_dir = NULL,
  out_stub = "gw"
)

```

**Arguments**

|              |  |
|--------------|--|
| surface      | A groundwater elevation SpatRaster.                          |
| res_factor   | Factor used to thin arrows by resampling to a coarser grid.  |
| scale        | Arrow length multiplier.                                     |
| min_gradient | Gradients below this value are dropped.                      |
| log_gradient | Store log1p() transformed gradient in the output raster.     |
| log_arrow    | Use log1p() transformed gradient for arrow lengths.          |
| out_dir      | Optional output directory. When supplied, files are written. |
| out_stub     | File prefix used when writing outputs.                       |

**Value**

A list with raster, points, and arrows.

**Examples**

```
data("synthetic_wells")
pts <- ps_make_points(synthetic_wells, "x", "y", "gw_elevation",
                     "well_id", "EPSG:26916")
s <- ps_interpolate(pts, methods = "IDW", grid_res = 100)
arrows <- ps_flow_arrows(s$IDW, res_factor = 4, scale = 60)
arrows$arrows
```

---

ps\_interpolate      *Interpolate potentiometric surfaces*

---

**Description**

Creates one raster per requested interpolation method. The default method is thin-plate spline ("TPS"). Other built-in methods are inverse distance weighting ("IDW"), ordinary kriging ("OK"), and universal kriging with quadratic drift ("UK"). Advanced users can also pass named custom interpolation functions through custom\_methods.

**Usage**

```
ps_interpolate(
  points,
  value = "Z",
  methods = "TPS",
  grid_res = NULL,
  template = NULL,
  mask = NULL,
  padding = NULL,
  idw_power = 2,
  idw_nmax = 15,
```

```

tps_lambda = NULL,
kr_auto_cutoff = TRUE,
kr_cutoff = NA_real_,
kr_width = NA_real_,
custom_methods = NULL,
x = "x",
y = "y",
name_col = NULL,
crs = NULL
)

```

### Arguments

|                     |   |
|---------------------|---|
| points              | A point SpatVector, sf object, or coordinate table with a data column to interpolate.   |
| value               | Data column name when points is not already standardized. Defaults to "Z".  |
| methods             | Character vector of interpolation methods. Built-in values are "TPS", "IDW", "OK", and "UK". Names supplied in custom_methods can also be used.   |
| grid_res            | Output raster cell size in map units.   |
| template            | Optional template SpatRaster; overrides grid_res, padding, and mask extent construction.  |
| mask                | Optional AOI polygon used to crop and mask output rasters.  |
| padding             | Padding added around the convex hull extent when building a template from points.   |
| idw_power, idw_nmax | IDW power and maximum neighbors.  |
| tps_lambda          | Thin-plate spline smoothing parameter. NULL lets fields::Tps() choose by GCV.   |
| kr_auto_cutoff      | Use automatic variogram cutoff and lag width.   |
| kr_cutoff, kr_width | Manual variogram cutoff and lag width.  |
| custom_methods      | Optional named list of custom interpolation functions. Each function is called as fun(points, template, grid) and must return either a SpatRaster matching template or a numeric vector with one value per template cell. |
| x, y, name_col, crs | Used when points is a coordinate table.   |

### Value

A named list of SpatRaster surfaces.

### Examples

```

data("synthetic_wells")
pts <- ps_make_points(synthetic_wells, "x", "y", "gw_elevation",
                     "well_id", "EPSG:26916")
surfaces <- ps_interpolate(pts, grid_res = 100)
names(surfaces)

```

---

ps\_make\_points      *Make groundwater observation points*

---

### Description

Convert a coordinate table, sf point object, or terra vector to a SpatVector with standard Z and Name fields.

### Usage

```
ps_make_points(data, x = "x", y = "y", value, name_col = NULL, crs = NULL)
```

### Arguments

|          |   |
|----------|---|
| data     | A data frame, sf object, or terra::SpatVector.                      |
| x, y     | Coordinate column names for tabular data.                           |
| value    | Groundwater elevation column name.                                  |
| name_col | Optional well or station name column.                               |
| crs      | Coordinate reference system for tabular data, such as "EPSG:26916". |

### Value

A point terra::SpatVector with standardized attributes.

### Examples

```
data("synthetic_wells")
pts <- ps_make_points(
  synthetic_wells,
  x = "x", y = "y",
  value = "gw_elevation",
  name_col = "well_id",
  crs = "EPSG:26916"
)
pts
```

---

ps\_potentiometric\_points      *Build potentiometric points from depth-to-water measurements*

---

### Description

Calculates groundwater elevation as surface elevation minus depth to water. Surface elevation can come from a DEM raster, a column in the depth table, or separate surface-elevation points. Separate surface points are matched by name when possible; otherwise their elevations are interpolated to the depth points with inverse distance weighting.

**Usage**

```
ps_potentiometric_points(
  data,
  x = "x",
  y = "y",
  depth_col,
  surface = NULL,
  surface_col = NULL,
  name_col = NULL,
  surface_name_col = name_col,
  crs = NULL,
  idw_power = 2
)
```

**Arguments**

|                  |  |
|------------------|--|
| data             | Depth-to-water observations as a data frame, sf, or terra::SpatVector.                       |
| x, y             | Coordinate column names for tabular depth data.  |
| depth_col        | Depth-to-water column name. Positive values are assumed to be depth below land surface.      |
| surface          | A DEM SpatRaster, separate surface-elevation observations, or NULL when surface_col is used. |
| surface_col      | Surface-elevation column in data, or in surface when surface is a point/table object.        |
| name_col         | Optional name column in data.  |
| surface_name_col | Optional name column in separate surface observations.                                       |
| crs              | CRS for tabular depth data.  |
| idw_power        | Power used when interpolating separate surface points.                                       |

**Value**

A point terra::SpatVector with surface\_elevation, depth\_to\_water, and Z groundwater elevation fields.

**Examples**

```
data("synthetic_wells")
data("synthetic_dem")
gw <- ps_potentiometric_points(
  synthetic_wells,
  x = "x", y = "y",
  depth_col = "depth_to_water",
  surface = synthetic_dem,
  name_col = "well_id",
  crs = "EPSG:26916"
)
head(terra::values(gw))
```

---

ps\_quicklook                      *Draw a quicklook surface plot*

---

### Description

Draw a quicklook surface plot

### Usage

```
ps_quicklook(  
  surface,  
  contours = NULL,  
  points = NULL,  
  file = NULL,  
  title = "Potentiometric surface",  
  label_points = TRUE,  
  width = 1600,  
  height = 1200,  
  res = 180  
)
```

### Arguments

|                    |  |
|--------------------|--|
| surface            | A SpatRaster.  |
| contours           | Optional contour SpatVector.                                     |
| points             | Optional observation point SpatVector.                           |
| file               | Optional PNG output path. When NULL, plots to the active device. |
| title              | Plot title.  |
| label_points       | Label points with Name and Z.                                    |
| width, height, res | PNG dimensions and resolution.                                   |

### Value

Invisibly returns file.

### Examples

```
data("synthetic_wells")  
pts <- ps_make_points(synthetic_wells, "x", "y", "gw_elevation",  
                     "well_id", "EPSG:26916")  
s <- ps_interpolate(pts, methods = "IDW", grid_res = 100)  
ps_quicklook(s$IDW, points = pts, title = "Synthetic IDW")
```

---

ps\_sample\_aoi      *Make the sample area-of-interest polygon*

---

**Description**

Make the sample area-of-interest polygon

**Usage**

```
ps_sample_aoi()
```

**Value**

A terra::SpatVector polygon in EPSG:26916.

**Examples**

```
aoi <- ps_sample_aoi()
aoi
```

---

ps\_smooth\_surface      *Smooth a potentiometric surface raster*

---

**Description**

Applies a focal moving-window smoother to a potentiometric surface raster. This can be useful when an interpolated surface is technically valid but too locally rough for contour development or hydraulic-gradient visualization.

**Usage**

```
ps_smooth_surface(  
  surface,  
  window_size = 3,  
  method = c("mean", "median"),  
  weights = NULL,  
  iterations = 1,  
  na.rm = TRUE,  
  preserve_na = TRUE,  
  filename = "",  
  overwrite = FALSE  
)
```

**Arguments**

|             |  |
|-------------|--|
| surface     | A terra::SpatRaster potentiometric surface.  |
| window_size | Odd integer window size used when weights is NULL.   |
| method      | Smoothing statistic. Supported values are "mean" and "median".   |
| weights     | Optional odd-dimension numeric matrix of focal weights. NA values in the matrix are ignored by terra::focal(). |
| iterations  | Number of smoothing passes.  |
| na.rm       | Ignore missing values inside the focal window.   |
| preserve_na | Preserve the original NA footprint after smoothing.  |
| filename    | Optional output raster filename.   |
| overwrite   | Overwrite filename when it exists.   |

**Value**

A smoothed terra::SpatRaster.

**Examples**

```
data("synthetic_wells")
pts <- ps_make_points(synthetic_wells, "x", "y", "gw_elevation",
                     "well_id", "EPSG:26916")
s <- ps_interpolate(pts, grid_res = 100)
smoothed <- ps_smooth_surface(s$TPS, window_size = 5)
smoothed
```

---

|               |                             |
|---------------|-----------------------------|
| synthetic_dem | <i>Synthetic DEM raster</i> |
|---------------|-----------------------------|

---

**Description**

A small artificial DEM matching synthetic\_wells, stored as a packed terra raster. Use terra::rast(synthetic\_dem) to unpack it.

**Usage**

```
synthetic_dem
```

**Format**

A terra::PackedSpatRaster with one layer named surface\_elevation.

**Examples**

```
data("synthetic_dem")
dem <- terra::rast(synthetic_dem)
dem
```

---

`synthetic_surface_points`*Synthetic surface elevation measurement points*

---

**Description**

Artificial land-surface elevation points for demonstrating workflows that do not start with a DEM raster.

**Usage**`synthetic_surface_points`**Format**

A data frame with coordinate, surface-elevation, and name columns.

**Examples**

```
data("synthetic_surface_points")
head(synthetic_surface_points)
```

---

`synthetic_wells`*Synthetic groundwater monitoring wells*

---

**Description**

A real-looking artificial monitoring dataset with coordinates, land-surface elevation, depth to water, and calculated groundwater elevation.

**Usage**`synthetic_wells`**Format**

A data frame with 32 rows and 6 columns:

**well\_id** Synthetic well identifier.

**x** Easting in EPSG:26916 map units.

**y** Northing in EPSG:26916 map units.

**surface\_elevation** Land-surface elevation.

**depth\_to\_water** Depth to groundwater below land surface.

**gw\_elevation** Groundwater elevation.

**Examples**

```
data("synthetic_wells")  
head(synthetic_wells)
```

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