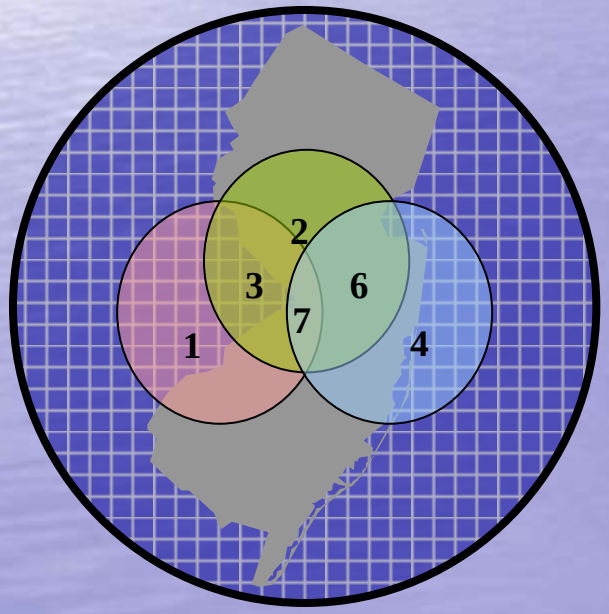
Remedial Priority System

Ground Water Site Condition Score And Exceedance Quotient

March 2012



Definitions: Exceedance Quotient vs Site Condition Scores

- An **exceedance quotient** (EQ) is a normalized value that enables SRP to compare analytes with different properties and different concentrations across distance and time. Each analyte that is sampled will be converted into an EQ.

- An **Site Condition Score** is one value that represents the site and is calculated using the Exceedance Quotients.

GW Site Condition Scores

- The Site Condition Score is created using the electronic sampling results submitted to the Department and one value is produced for each media evaluated by the RPS Model.

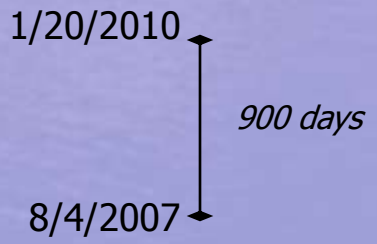
- At this time, there are three Media evaluated as part of the RPS Model.

    - **Ground Water**
    - **Soil**
    - **Vapor**

Calculate the GW Site Condition Score

What data are used to calculate the GW Site Condition Score:

- The RPS only uses the latest sampling round and all other events within 900 days of that sampling event to determine the GW Site Condition Score
  - Example: Last Sample Round was 1/20/2010



  - All results between 8/4/2007 and 1/20/2010 would be used to calculate the ground water Site Condition Score

- Reasons for 900 days:
  - Limit the time of sample reviews to ensure only most recent samples are being considered in calculations
  - 900 days would consist of 10 rounds of quarterly monitoring

Calculate the GW Site Condition Score

- An **exceedance quotient** (EQ) is calculated for each ground water result that exceeds the Ground Water Quality Standards (GWQS)

Calculate the GW EQ

Exceedance quotient Calculation

Adjustments to the initial concentration

- Solubility:
  - Water Solubility (S) is "… the equilibrium distribution of a solute between water and solute phases at a given temperature and pressure. Because S is the maximum solute concentration possible at equilibrium, it can function as a limiting factor in concentration-dependent processes." Pontolillo and Eganhouse, 2001 from USGS Toxic Substances
- Mobility:
  - Retardation factor (R) *1 is the ratio of the groundwater seepage velocity to the rate that organic chemicals migrate in the ground water.
- Degradation:
  - Half-life ($t_{1/2}$) *1 is the period of time required for an analyte to decrease by half.

*1 **a retardation and half-life are calculated for each compound based on typical aquifer characteristics**

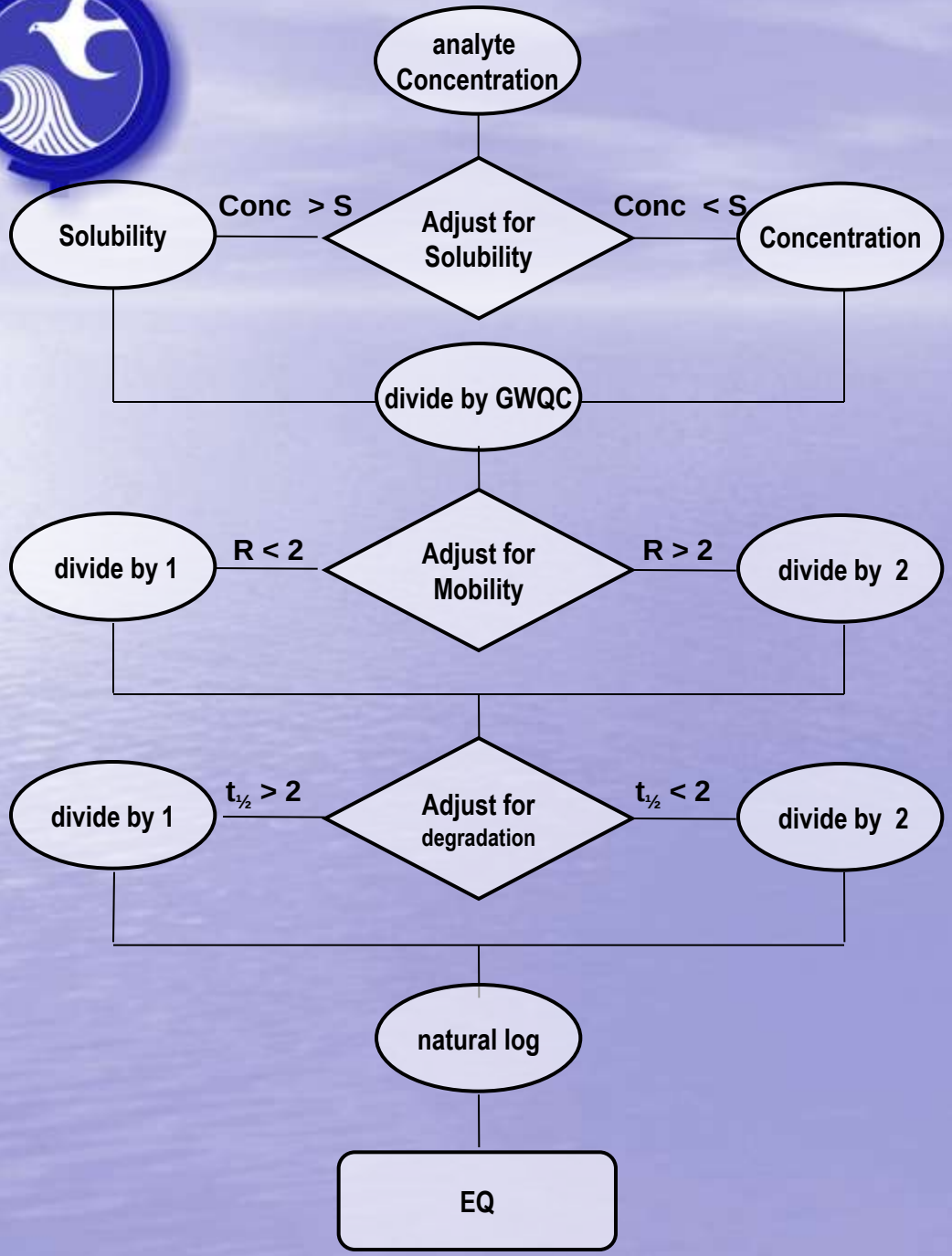
Calculate the GW EQ

Exceedance quotient Calculation

Adjustments to the initial concentration

- Health based Ground Water Quality Criteria:
  - Ground Water Quality Criteria (GWQC)
- Natural Log:
  - Ground water contamination at a site has a log-normal distribution. The natural log is used to normalize the value.

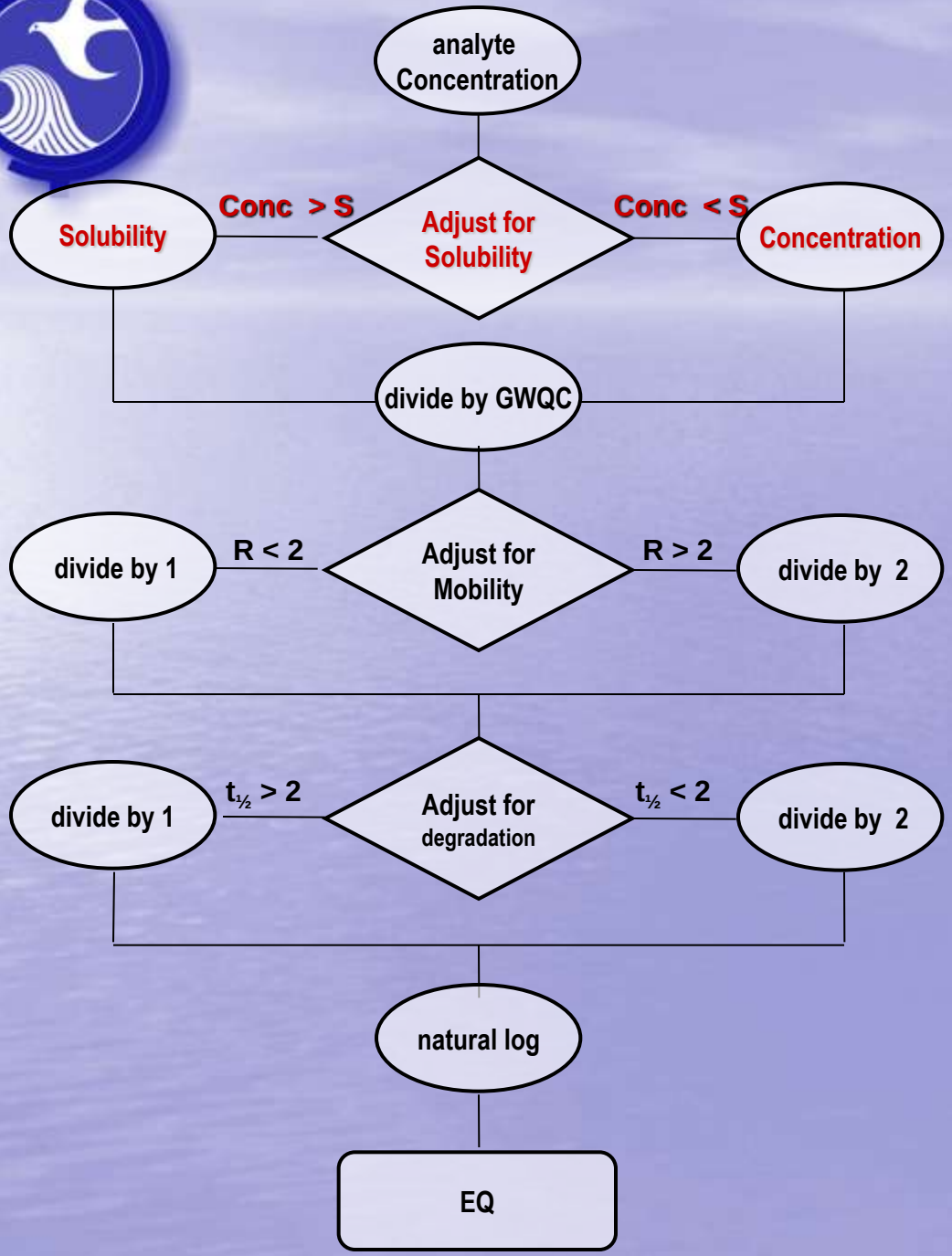
Method to Calculate GW EQ



Legend

GWQC = Ground Water Quality Criteria
R = Retardation Factor
S = Solubility
t½ = Half Life (years)

Calculate GW EQ



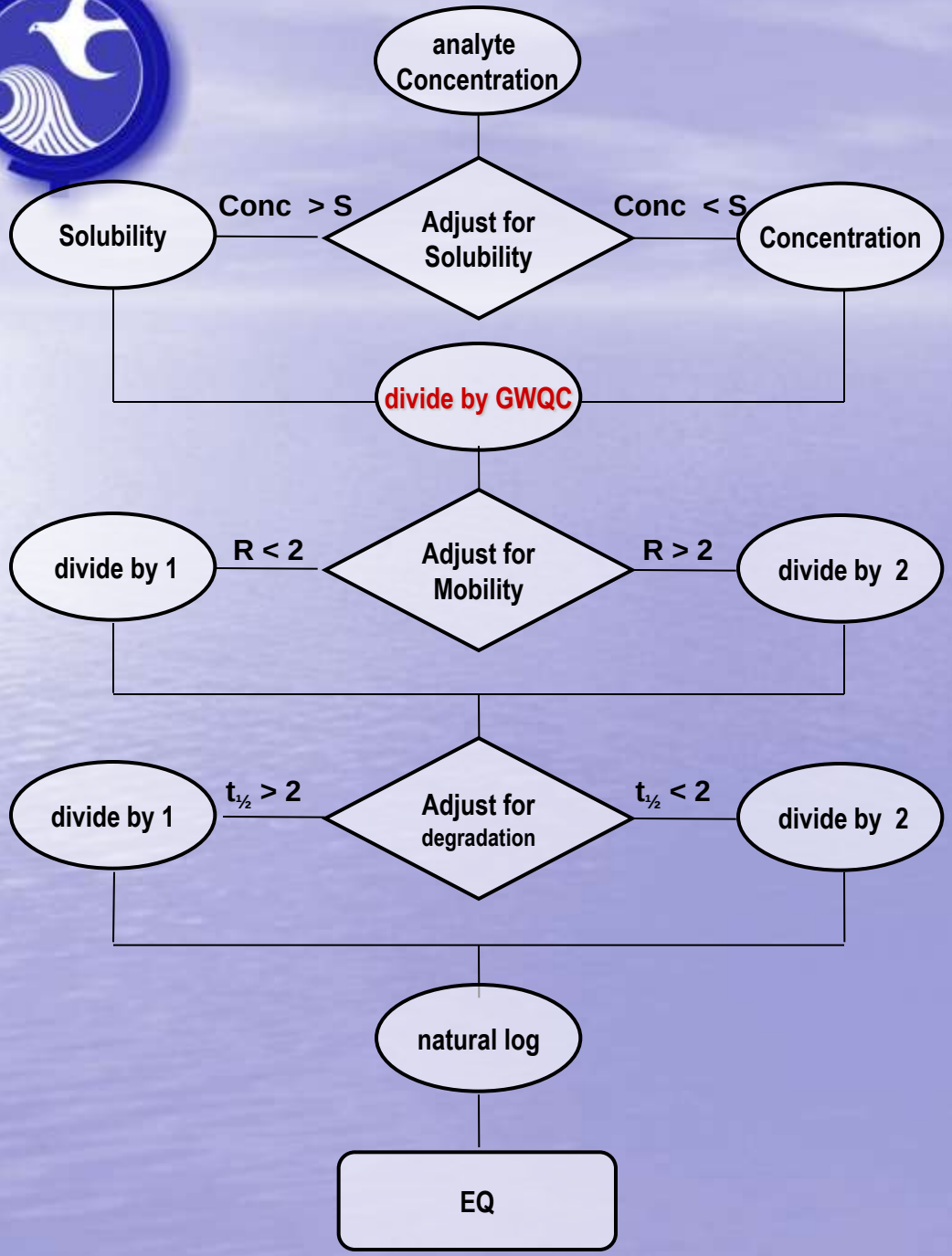
1. Adjust for Solubility

Start with the analyte concentration (if it exceeds the appropriate GWQS in a well)

Compare the concentration to the analyte's solubility

- **If the solubility is lower than the concentration, then substitute the solubility for the concentration.**
- **If the solubility is greater than the concentration, then use the analyte concentration.**

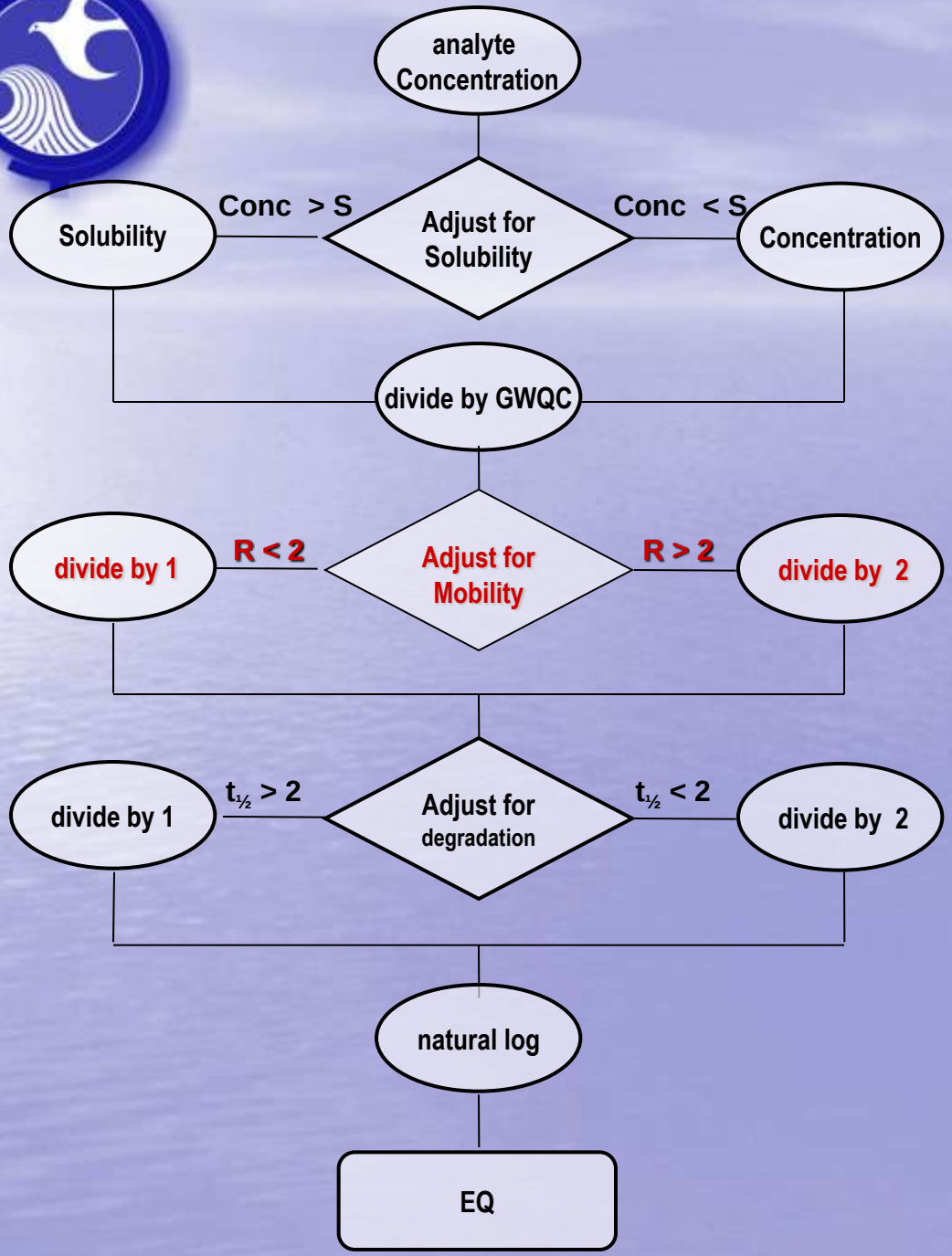
GW EQ Steps



2. Compare to GWQC

Divide the value that was calculated from the last step by the health based Ground Water Quality Criteria (GWQC).

GW EQ Steps

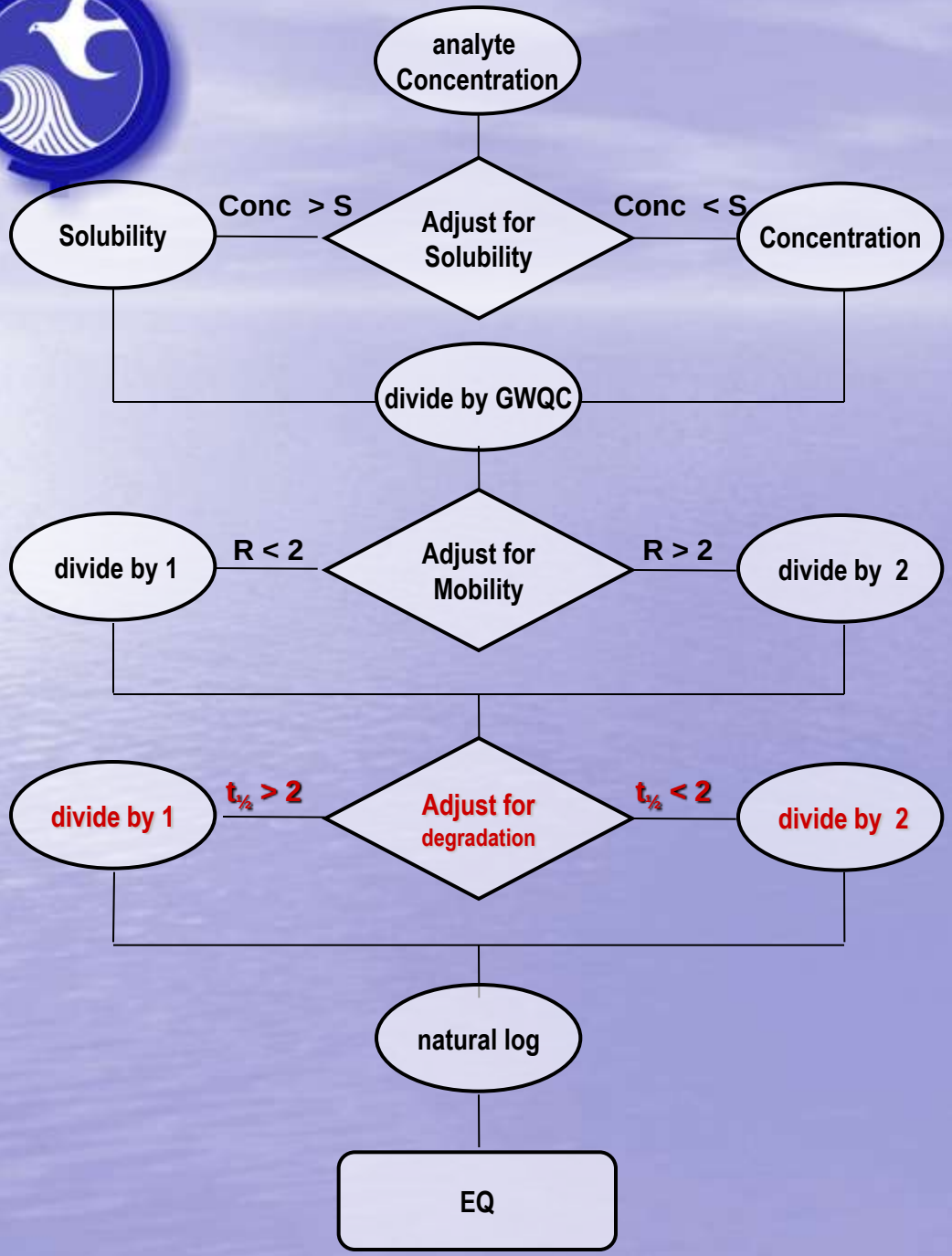


3. Adjust for Mobility

Evaluate the Retardation Factor for the compound.

- **If the Retardation Factor is greater than 2 for the compound, then divide by 2**
- **If the retardation Factor is less than or equal to 2 for the compound, then divide by 1.**

GW EQ Steps

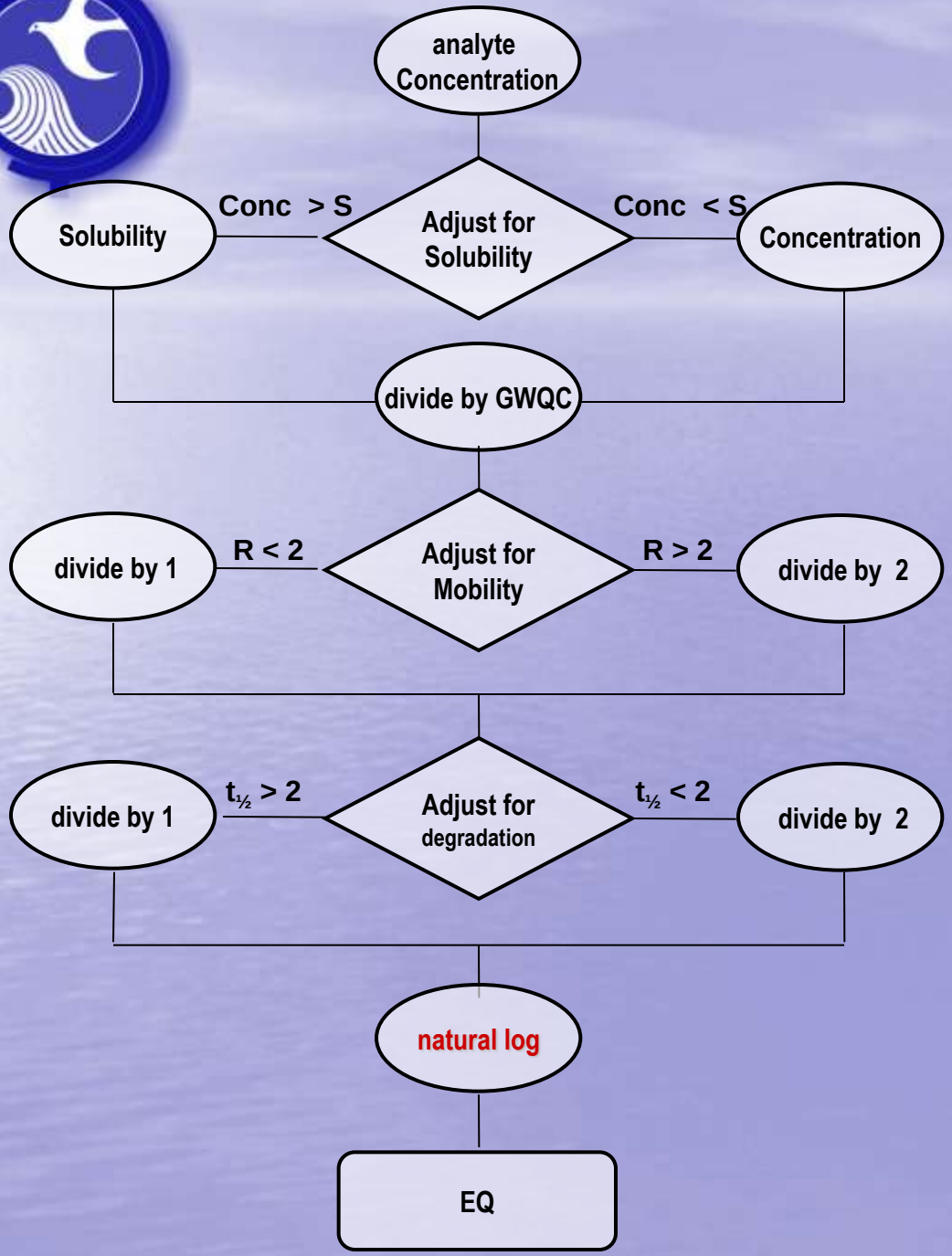


4. Adjust for degradation

Evaluate the half life of the analyte.

- **If the half life for the analyte is less than 2 years, then divide by 2.**
- **If the half life for the analyte is greater than or equal to 2 years, then divide by 1.**

GW EQ Steps



5. Natural Log

Calculate the natural log of the previous value.

- **The natural log is used to normalize the value. Ground water contamination usually has a log normal distribution in nature. This step is used to normalize the results.**

The result is the EQ for that sample result

Calculate the GW Site Condition Score

- The process to calculate a Site Condition Score for Ground Water includes 2 steps:
  - **Step 1**
    - calculate the average of the EQ for each analyte for each well
  - Step 2
    - calculate a 95% upper confidence limit (UCL) for the average of the EQs calculated in Step 1

Notes:
- If there is an exceedance for an analyte in a well, then all of the results during the 900 day period will be used to evaluate that analyte.

Calculate the GW EQ

- Calculate the EQ using solubility, mobility, degradation, and other characteristics that affect travel time and distance.

- Example Dataset:

Well	Analyte	Conc (ppb)	Evaluate Solubility		Evaluate GWQC		Evaluate Mobility		Evaluate Degradation		Natural Log	EQ
			Value	Result	Value	Result	Value	Result	Value	Result		
	Test		If S>Conc then Conc If S>Conc then S		Divide by GWQC		If R>2 then X 0.5 If R<2 then X 1		If $t_{1/2}$<2 then X 0.5 If $t_{1/2}$>2 then X 1			
MW-1	Benzene	5,000	1,780,000	5,000	.2	25,000	R < 2	25,000	$T_{½}$ < 2	12,500	9.43	9.43
MW-1	Toluene	5,000	535,000	5,000	600	8.33	R > 2	4.16	$T_{½}$ < 2	2.08	0.73	0.73
MW-1	Xylenes	50,000	175,000	50,000	1000	50	R > 2	25	$T_{½}$ < 2	12.5	2.53	2.53
MW-2	TCE	20	1,100,000	20	1	20	R > 2	10	$T_{½}$ > 2	10	2.30	2.30
MW-4	PCE	1,500	200,000	1,500	0.4	3,750	R < 2	3,750	$T_{½}$ > 2	3,750	8.23	8.23

Calculate the GW Site Condition Score

- The process to calculate a Site Condition Score for Ground Water includes 2 steps:
  - Step 1
    - calculate an average EQ for each analyte for each well
  - **Step 2**
    - **calculate a 95% upper confidence limit (UCL) for the average of the EQs calculated in Step 1**

Notes:

- Calculate a 95% UCL of the averages previously calculated for the rounds of wells and analytes.
- If there are less than 4 samples, the mean will be used.
- If there are 4 or more samples, then the 95% Upper Confidence Level will be used.

Calculate the GW Site Condition Score

Calculate a 95% UCL of all the UCLs previously calculated for the rounds of wells and contaminants. There is now one UCL for the entire site.

- Example Dataset

analyte	Well	EQs
Benzene	MW-1	9.43
Toluene	MW-1	0.73
Xylenes	MW-1	2.53
TCE	MW-2	2.30
PCE	MW-4	8.23

Sample Count	Average	Standard Deviation	Significant Interval	95% UCL
5	4.64	3.91	3.42	8.07

Ground Water SCS = 8.07

The Site Condition Score for Ground Water is the 95% UCL

Calculate the GW Site Condition Score

- Assorted Notes:

- If a Site Condition Score is negative, 0.001 is substituted for the final Site Condition Score. The replacement of the negative value is needed to make sure that all of the numbers are positive.

- Negative EQ values are used to Calculate the 95% UCL.