Purolite® is at the forefront in meeting new challenges in removing contaminants from potable and groundwater. This updated brochure looks at Purolite specialized ion exchange resins and adsorbent solutions that help reduce waste and operating costs. New solutions for disinfection byproduct control, hexavalent chromium and arsenic removal are presented.
POTABLE & GROUNDWATER TREATMENT

Inside this Application Guide, you will find an overview of Purolite resins for removing contaminants from potable and groundwater systems. For more detailed information on any product, or to find a product for an application not mentioned, visit www.purolite.com or contact the closest Purolite regional office listed on the back cover.

INTRODUCTION

Founded in 1981, Purolite is a leading manufacturer of ion exchange, catalyst, adsorbent and specialty resins. With global headquarters in the United States, Purolite is the only company that focuses 100% of its resources on the development and production of resin technology.

Responding to the needs of our customers, Purolite has built the largest technical sales force in the industry, the widest variety of products and five strategically located Research and Development groups. Our ISO 9001 certified manufacturing facilities in the U.S.A, Romania and China combined with more than 40 sales offices in 30 countries ensure complete worldwide coverage.

PREMIER PRODUCTS

The quality and consistency of our products is fundamental to our performance. Throughout all Purolite plants, production is carefully controlled to ensure that our products meet the most stringent criteria, regardless of where they are produced.

RELIABLE SERVICE

We are technical experts and problem solvers. Reliable and well trained, we understand the urgency required to keep businesses operating smoothly. Purolite employs the largest technical sales organization in the industry.

INNOVATIVE SOLUTIONS

Our continued investment in research & development means we are always perfecting and discovering innovative uses for ion exchange resins and adsorbents. We strive to make the impossible possible.
Improvement in detection levels for contaminants in potable and groundwater has led to mandated control of more contaminants by regulatory bodies around the world. New and tightened limits have been introduced for contaminants such as arsenic, perchlorate and uranium, and more is understood about monitoring and control requirements or disinfection byproducts (DBP) such as trihalomethanes (THM) and haloacetic acids (HAAS), which are formed in some waters by the addition of chlorine and chlorine derivatives. As a result, increased requirements for removal of naturally occurring organic matter (TOC) before disinfection are now being applied to some waters.

In arid regions, more attention is being paid to treatment processes that minimize the environmental impact of wastewater and chemical discharge—including spent regenerant chemicals.

PuroLite® products help you meet these new challenges through specialized ion exchange resins and adsorbent solutions focused on reducing waste and operating costs. The wide variety of contaminants needing removal often requires a customized approach. Some contaminants are removed by relying largely on the ion exchange properties of our resins (e.g. nitrate and uranium) while others (e.g. perchlorate and TOC) rely on the combination of unique ionic, adsorptive and hydrophobic characteristics of our specialty resins. Table 1 presents recommended treatment approaches for some of the major currently regulated contaminants.

### Table 1 – PuroLite range of ground and potable water treatment resins

<table>
<thead>
<tr>
<th>CONTAMINANT</th>
<th>PUROLITE PRODUCT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bromide</td>
<td>Bromide Plus™/9218</td>
<td>Regenerable selective resin for reducing bromide and the subsequent potential formation of bromomethanes and bromate.</td>
</tr>
<tr>
<td>Nitrate</td>
<td>A300E, A520E A600E/9149</td>
<td>Nitrate selective, Type II SBA, Type I SBA.</td>
</tr>
<tr>
<td>Hexavalent chromium</td>
<td>A600E/9149 S106</td>
<td>Type I brine regenerable SBA Single-use WBA requiring pH adjustment</td>
</tr>
<tr>
<td>Perchlorate, technetium</td>
<td>A530E, A532E, A850</td>
<td>Perchlorate selective resins (can also use A520E, A600E).</td>
</tr>
<tr>
<td>Arsenic</td>
<td>FerrIX™ A33E A200E, A300E</td>
<td>Iron oxide-infused adsorbent resin; single use or off-site regenerable. Type II SBA – brine regenerable.</td>
</tr>
<tr>
<td>Uranium</td>
<td>A200E, A300E, A400E A600E/9149, A850</td>
<td>Brine regenerable or single use.</td>
</tr>
<tr>
<td>Barium / radium / strontium</td>
<td>SSTC60, SSTC65, SSTC80 PPC100E</td>
<td>Fouling resistant shell-core, brine regenerable SAC. Narrow particle size SAC for packed beds.</td>
</tr>
<tr>
<td>Iron &amp; manganese</td>
<td>SSTC60</td>
<td>Fouling resistant Shallow Shell™ core SAC, brine regenerable; handles up to 20 ppm Fe.</td>
</tr>
</tbody>
</table>
Organics and bromide removal for control of disinfection byproducts

Naturally occurring organic matter such as humic, fulvic and tannic acids that are present in water being disinfected can potentially result in the formation of a variety of toxic byproducts. These include trihalomethanes (THM) and haloacetic acids (HAA5). Elevated levels of bromide can lead to the formation of bromomethanes and bromate. Levels of THM, HAA5 and bromate are all currently regulated in several countries. In the USA maximum concentrations of 80 ppb THM, 60 ppb HAA5 and 10 ppb bromate are allowable.

Purolite offers a variety of brine regenerable anion resins that can remove organic matter (collectively known as total organic carbon or TOC). The degree of reduction depends on the specific nature of the TOC as well as the choice of resin, its porosity, contact time and resistance to irreversible fouling. As a result, our product offering includes acrylic SBA resins (Purolite A860 macroporous) as well as Purolite A502P, a macroporous styrenic SBA. For more difficult-to-treat systems that have both colloidal and dissolved TOC, we recommend Tanex™, a proprietary blend of resins, inclusive of a patented scavenger resin for colloidal particulate matter removal.

An increasing number of raw water supplies are showing higher levels of bromide. Disinfecting water supplies containing both organic matter and bromide can potentially lead to the formation of disinfection byproducts such as bromomethanes and bromate. Purolite® Bromide Plus™/9218 is a proprietary bromide selective resin that is regenerable using sodium chloride and other chemicals for regeneration. Removal plants must be custom designed with the help of our technical experts. Depending on the circumstances, we can design for joint removal of bromide and organic matter while using a common regenerant. This simplifies design while allowing for reduction in capital and operating costs. Proper system design is important for good performance in all cases.

Advantages of our ion exchange resins for organics and bromide removal include:

- Low operating cost with simple system design, requiring minimum operator attention.
- Multiple brine reuses possible in order to minimize the volume of waste water.
- Layering of anion resin on top of cation softening resin is possible to help reduce footprint and capital and operating costs.
- Multi-contaminant design approach is possible for simultaneous removal with other contaminants.

Nitrate removal

The World Health Organization (WHO) recommends a maximum limit for nitrate of 50 ppm as NO₃ while the USA and some other countries have set a maximum MCL of 10 ppm as N (or 45 ppm as NO₃).

Nitrate removal using brine regenerable strong base anion resins is an established process. Nitrate selective resins, such as our Purolite A520E, were developed for use specifically in waters with high sulfate to nitrate ratios. For waters with low sulfate levels, our Purolite A300E Type II SBA resin may offer better economics. Our high-capacity Type I SBA A600E/9149 can also be used. Purolite A520E is favored, however, because nitrate fixed onto the bed is not displaced from Purolite A520E by sulfate as is the case for traditional Type I and II resins. Larger plants that are well controlled should evaluate both nitrate selective and standard Type I and II resins since the specific water chemistry will dictate which will yield the lowest operating cost.

Our technical experts can help by analyzing costs through our PureDesign™ economic comparison software.

For municipal or community water systems where on-site brine disposal is not permitted, hauling and off-site disposal of waste brine can be cost
prohibitive. To address this, Purolite and Applied Research Associates have jointly developed the patented WIN process for nitrate removal, using proprietary weak base anion resin technology. The WIN process, while requiring more operator attention, can significantly reduce waste volume compared to brine regenerable resins while producing more benign nitrate waste.

Advantages of Purolite ion exchange resins for nitrate removal include:

- Single supplier for the full range of resin options available to the industry.
- Reliable easy-to-use PureDesign™ software for ease of design.
- Customizable brine minimization approaches.
- Multi-contaminant design approach is possible for simultaneous removal with other contaminants.

Hexavalent chromium removal

Chromium is a heavy metal that occurs throughout the environment. The trivalent form is a required nutrient, while the hexavalent form, also commonly known as Chromium (VI), CR(VI), Chrome 6 or Cr-6, is a known carcinogen and an emerging health concern for groundwater. Treatment options should be chosen carefully as technologies are sensitive to water conditions.

Key Factors affecting treatment include alkalinity, sulfate, TOC, Cr-6 and uranium levels. Costs associated with equipment, residual disposal and operational preferences can affect the selection of treatment and process.

Purolite offers two industry-leading solutions that work within a variety of site and operational conditions. Regenerable Purolite A600E/9149 or single-pass Purolite S106 can provide cost-effective solutions for reducing or eliminating contamination to meet compliance with state and federal maximum contaminant levels (MCLs).

Purolite A600E/9149 is a Type I strong base anion (SBA) gel ion exchange resin. A600E/9149 exchanges Cr-6 anions for less strongly held chloride ions on the resin beads and requires periodic regeneration with salt solution (brine) and disposal and/or treatment of the Cr-6 laden brine. Regeneration frequencies of between 5,000 and 25,000 bed volumes can be achieved between regenerations, depending on the influent water chemistry.

Single-pass load and dispose systems do not utilize an on-site regeneration process, and are ideal in locations with significant constraints or where accessibility to brine disposal options is limited. After the resin is spent, it can be sent to a landfill for disposal or transferred to a chrome recovery facility. Resin will then be replaced for on-going treatments.

Purolite S106 is a single-pass epoxy polyamine weak base anion resin (WBA) that exhibits excellent selectivity and kinetics in the removal of ppb levels of hexavalent chromium from aqueous streams.

Purolite S106 must undergo a protonation pre-treatment of the weak base anion exchange sites to activate the resin’s ability to function as an ion exchanger and to optimize pH levels, especially in water with high alkalinity. Operation of two ion exchange vessels in a lead-lag fashion within a pH range of 5.0 to 6.0 is usually adequate to achieve maximum effective use of the exchange sites and meet targeted MCLs in the finished treated water. A reduction of over 99% can be achieved when operating at a service flow-rate of 20 bed volumes per hour. Resin can treat between 100,000 and 300,000 bed volumes between replacements.

Pre-treatment, disposal costs and environmental impact are always concerns when using WBA resin, — especially if uranium loading may further limit disposal options. However WBA resin is a highly effective treatment, particularly under process constraints.

Advantages of Purolite ion exchange resins for hexavalent chrome removal include:

- Single supplier for the full range of resin options available in the industry.
- Reliable modeling software for ease of design, capacity and operational expectations.
- Customizable brine minimization approach or single-pass approach.
- Multi-contaminant design approach is possible for simultaneous removal with other contaminants.
- Full service capabilities for resin installation, removal and disposal.
Perchlorate removal

Perchlorate is a major health issue, particularly in the USA. Trace parts per billion levels have been detected in potable water supplies in at least 22 states. Even though the US EPA has yet to set a MCL, perchlorate is now regulated by several states at maximum levels ranging from 1 ppb to 6 ppb.

Purolite continues to lead the industry with a comprehensive line of single-use and regenerable resins for perchlorate removal. Below is a listing of the major resins used for remediation of contaminated ground or potable water:

- Purolite A532E – single use “load & burn”
- Purolite A530E – single use or regenerable*
- Purolite A520E – single use or regenerable*
- Purolite A850 – brine regenerable

* Regeneration is possible using a tetrachloroferrate process patented by Oak Ridge National Laboratories and available from third parties.

Also, in conjunction with Applied Research Associates, we offer our WIP perchlorate removal process, using patented regenerable weak base anion resin technology. This technology is ideally suited for elevated levels of perchlorate (e.g. 100 to 1,000 ppb and higher). The technology has also been demonstrated to simultaneously remove perchlorate and nitrate and has the capability to remove other oxyanions (e.g. selenate, chromate, molybdate, pertechnetate, perrhenate).

Purolite A532E and Purolite A530E are hydrophobic anion resins that offer the highest selectivity for perchlorate and pertechnetate.

Purolite A532E and Purolite A530E are hydrophobic anion resins that offer the highest selectivity for perchlorate and pertechnetate.

Purolite provides a full array of services with experienced personnel for handling all resin operations to end users and OEMs.

In the USA, we utilize our bulk tankers for fast and efficient unloading and loading of resins. We contract with approved facilities for disposal of spent resins by incineration and can provide a final certificate to show proper waste resin disposal, using full chain-of-custody controls.

Advantages of Purolite ion exchange resins for perchlorate removal include:

- Low operating cost with simple system design, requiring minimum operator attention.
- Reliable capacity projections available using proprietary simulator software combined with field data.
- Customizable solution for simultaneous removal of other oxyanions.
- Single responsible source, providing full-service capability for all resin operations.

Arsenic removal

Arsenic is a toxic substance with varying degrees of regulation. The standard MCL for arsenic in drinking water for the USA is 10 ppb.

FerrIX A33E is an iron-infused anion resin that uses iron oxide to complex and remove pentavalent and trivalent arsenic from water. FerrIX A33E reduces arsenic levels to < 2 ppb and is ideal for municipal treatment plants, point-of-entry (POE) and point-of-use (POU) systems. It is compatible with most existing lead-lag or parallel design configurations and is recommended for either single use or for applications needing off-site regeneration.

For water systems where brine regeneration is feasible, we recommend Purolite A300E or A200E anion resins to remove only the pentavalent form of arsenic. Pre-oxidation is recommended for converting the trivalent to the pentavalent form before removal by the resin. Any excess of oxidant must be removed before contact with the resin.
Uranium removal

Uranium, a naturally occurring radionuclide found in both surface and groundwater, is a known human carcinogen with a current MCL of 30 ppb. Uranium has an extremely long half-life of approximately 4.5 billion years eventually emitting large radioactive alpha particles, which cannot penetrate the skin but can be a significant internal hazard if ingested or inhaled.

Uranium usually exists as anionic uranyl carbonate or uranyl sulfate complexes. These complexes are either divalent or tetravalent in ionic charge depending on the system pH. As a result, most strong base anion resins show extremely high selectivity. Operating capacity is directly impacted by sulfate concentration in the water, with capacities typically ranging from 10,000 to 200,000 bed volumes and even higher. Using our PureDesign software, we can predict the operating capacity for our various resins based on influent water chemistry.

Recommended products include: Purolite A300E or Purolite A200E Type II Styrenic SBA resins, Purolite A400E and Purolite A600E/9149 Type I Styrenic SBA resins, and Purolite A850 Type I Acrylic SBA resin.

Brine regeneration of uranium loaded resin is a feasible option, using 10% or higher brine concentration and salt dosages ranging from 160 to 240 g/l (10 to 15 lb/ft³), depending on the specific job requirements.

Another option is to use the resin once and dispose of it. If considering this option, it is important to note that the relevant regulatory requirements for handling and disposal of uranium loaded media for each location must be adhered to.

A handling and transportation license is required in many countries for instance if uranium will exceed a certain weight (0.05% in the USA) on the spent media. In addition, operators must comply with governing regulations on transportation and disposal at facilities approved for storing radionuclide waste.

Advantages of using Purolite resins for uranium removal include:
- Efficient software modeling capability for quick capacity estimates.
- In-house help with design criteria.
- Multi-contaminant design approach as needed for simultaneous removal of other contaminants.

Barium / radium / strontium removal

Radium-226, radium-228 and strontium-90 are radionuclides that are of major concern in many countries and currently regulated in the USA with a combined MCL for radium-226 and radium-228 of 5 picocuries/liter and a MCL of 8 picocuries/liter for strontium-90. Barium is regulated by the US EPA at 2 ppm maximum.

Although standard strong acid cation (SAC) resins can remove these divalent cations readily from water, the efficiency of standard brine elution is reduced from cycle to cycle due to the slow diffusion of their larger atomic mass deep into the matrix of the resin. The phenomenon is much more noticeable with barium, which is usually present in water in ppm concentrations. It can result in a buildup of precipitated barium salt within the resin beads in just a few months of operation, with the need to periodically remove the resin from service for specialist chemical cleaning with acid. Shallow Shell™ SSTC60 and Shallow Shell™ SSTC80 SAC resins are superior choices for this type of application due to the inert core that prevents deep fouling of the resin beads. The shorter diffusion path present in the SST® resin beads translates to quicker, more efficient elution of the cations and reduced fouling rate, resulting in lower overall operating costs.

For optimum performance, we usually recommend counter-flow regenerated ion exchange systems with a salt dosage of at least 240 g/l (15 lb/ft³) and a minimum brine contact time of 60 minutes.

Advantages of using Purolite ion exchange resins for barium, radium and strontium removal include:
- Inert core of Shallow Shell resins provide unique resistance to fouling.
- Shallow Shell resins provide superior elution and lower rinse volumes compared to standard SAC resins.
- In-house design recommendations.
Multi-contaminant removal — arsenic/nitrate/TOC/uranium

A water supply may often contain more than one contaminant that must be removed. In such cases, it may be cost effective to simultaneously remove the contaminants with either a single-use or a regenerable resin. Since several contaminants use brine regeneration, it is feasible to design for combined removal of contaminants.

For example, nitrate and arsenic or nitrate and uranium co-occur in several locations. We have participated in numerous design projects using a multi-contaminant approach for removing nitrate, uranium, arsenic, TOC and perchlorate in various combinations.

A similar design approach can be used for removal of cations combined with anions, such as hardness, barium, TOC and uranium. Our in-house capability to model the resin performance in the presence of these multi-contaminants can be used to optimize the final process design and minimize or eliminate the need for field pilot studies.

Advantages of Purolite ion exchange resins for multi-contaminant removal include:

- Simple ion exchange system that can handle at least four contaminants in a single vessel.
- Major reduction in footprint, capital and operating costs.
- Simple to operate plant with single waste volume to handle.

Simultaneous removal of arsenic, nitrate, TOC and uranium at City of McCook, NE treatment plant using brine regenerable resins.
Membrane protection resins –
Purolite MPR and
Shallow Shell™ SSTC65 technologies

While ion exchange resins can be used to selectively remove specific contaminants, membrane and other broad-based removal technologies are suitable alternatives for reduction of high total dissolved solids (TDS) in brackish water supplies. Membrane fouling from colloidal particulate matter, TOC and scale-forming compounds can limit the percentage of permeate water that is recoverable. Purolite’s membrane pretreatment resins can reduce colloidal particulates, TOC and scaling potential to give a lower silt density index (SDI) and increase membrane operating efficiency and recovery rate. The widespread use of reverse osmosis membrane technologies for remediation of groundwater presents an opportunity to apply our proprietary resin-based technology to protect the sensitive RO membranes from fouling and resulting loss in efficiency. Table 2 outlines our recommendations for membrane pretreatment.

For applications not listed, see back page for Purolite contact information.

Purolite MPR1000 is a brine regenerable proprietary mix of resins that can typically reduce SDI by greater than 40% and TOC by 50% to 80%—reducing power and membrane cleaning costs while increasing overall recovery and system reliability.

With use of proprietary Shallow Shell™ SSTC65 inert core SAC resin to remove divalent cations such as barium, hardness and iron from the feed, permeate water recovery rates are possible up to 90% to 95% higher. This is of special interest to arid regions where disposal options for RO concentrate are limited and where water supplies are scarce.

Further, the special structure of this resin allows cost-effective regeneration with just the reject brine from the RO, using Purolite’s Cyclic Ion Exchange (CIX-RO™) process. The shorter diffusion path of SST resins, compared to standard SAC resins, results in much greater elution efficiency for divalent cations. Relatively low RO reject brine concentrations (0.5%) can be used. Fouling by barium and strontium, typical within the core of standard SAC beads, is eliminated because of the inert core of this resin.

Purolite Shallow Shell™ Technology high-efficiency resin is an economical solution for treating hard water with high TDS, increasing the quantity of recoverable permeate water.

<table>
<thead>
<tr>
<th>MEMBRANE PRETREATMENT</th>
<th>PUROLITE RESINS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colloidal particulate reduction</td>
<td>MPR1000</td>
<td>A proprietary blend of patented colloidal scavenger and TOC removal resins.</td>
</tr>
<tr>
<td>Silt density index reduction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOC reduction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barium, strontium, hardness reduction</td>
<td>SSTC60, SSTC80</td>
<td>Fouling-resistant core, brine regenerable SAC.</td>
</tr>
<tr>
<td></td>
<td>SSTC65</td>
<td>Regenerable with RO reject water using Purolite’s Cyclic Ion Exchange (CIX-RO™) process or with standard brine.</td>
</tr>
</tbody>
</table>

Table 2 – Purolite recommendations for membrane pretreatment
By using this “natural free regenerant” approach, our CIX-RO process helps reduce environmental impact of commercial regenerants and water resources.

Advantage of membrane protection resins include:

- MPR1000 is a unique solution for improving operating efficiency.
- Potential to design smaller membrane plants for same job.
- CIX-RO process provides a “green technology” approach with minimal environmental impact.
- Potential to significantly increase membrane recovery rates and conserve scarce water resources.

**Cyclic ion exchange (CIX-RO™) process**
Purolite—the leading manufacturer of quality ion exchange, catalyst, adsorbent and specialty high-performance resins—is the only company that focuses 100% of its resources on the development and production of resin technology.

We’re ready to solve your process challenges. For further information on Purolite® products and services, visit Purolite.com or contact your nearest Technical Sales Office.