Rocky Hill Water Situation Section 4.

Review and Summary

Several weeks prior to the Dec 7th Council meeting it was suggested to the Mayor that he should communicate with the Mayor of Horsham with a mayor-to-mayor call asking about the results of their PFAS resin system they put into operation in late 2018.
There were a variety of questions he should ask, and that a Zoom or similar meeting with them should be arranged if possible for us to get a firm understanding of how their system had worked out and if there were any problems we should be aware of. A meeting with them could be quite important for us since they have already installed twin tank resin systems of the type we describe in Section 3 (posted on the website www.rockyhillwater2020.com) Their systems are stated to have been operational in Horsham already for more than 2 years.

There was no mention of this at the Dec 7th Council meeting, and the mayor was questioned on it at the ending brief question time.
It turned out there had indeed been a call to Horsham, and the statement was that they had a lot of Carbon systems (we know that already– they are a large community (7,800 water customers) they have 14 wells, and this was fully described in Section 2.)
The discussion with Horsham was going to be discussed at the next ad-hoc Water Committee meeting. Nothing has been mentioned since then, or anything mentioned in later Council meetings, up to and including the last one on Jan 20th.

The actual PFAS contamination situation in the Rocky Hill water was known in the Feb - March timeframe, and reported in the local (Montgomery News) press.
A hydro-geologist was apparently hired to find a new well and several ad-hoc committees were formed to discuss the matter.
The activity seems to be based on the premise that the Rocky Hill Water System needs to meet requirements for increased Capacity and for Backup.
[These are separate issues for later discussion.]

The actual real issue at present that has to be addressed is the newly discovered PFAS contamination in Rocky Hill water, and how to overcome it.

The initial crisis situation over PFAS is now rationalized to establish that Rocky Hill has only trace levels of PFAS and is out of compliance with the latest NJDEP limits (MCL values) for only one such chemical (PFOS) and then only by less than 3 parts per trillion.
It is also quite possible to eliminate PFAS contamination entirely from Rocky Hill water in a simple manner at very low cost. So the situation is far from being crisis.

The design of **ion exchange** filtration for the existing Rocky Hill aeration system has been described and presented in detail in three (3) sequential sections on the

website www.rockyhillwater2020.com intended for general access by the Rocky Hill community so everybody can read about it and understand the issues, and can download and print it all out for detailed analysis.

This design, incorporating the technology of ion exchange, totally eliminates PFAS contamination and takes advantage of the aeration stages in the Rocky Hill Water Facility to insert ion exchange filter modules in a simple manner. The system cost is quite low, totaling $ 25,000 overall for the filter units and the ion exchange resin. Full details are presented in **Section 3** on the above mentioned website.

Ion exchange, using the new types of ion exchange resin specifically formulated with PFAS extraction in mind, is a new approach but will become the method used extensively in the future, and will replace the use of activated carbon adsorption.

Ion exchange does not depend on adsorption. As the name implies it depends on the ion exchange process. This is described quite well in a simple primer article presented in **Section 1 on page 7.**
Based on the attraction forces between oppositely charged ions (namely electrostatic forces) - ion exchange does **NOT** involve the EBCT contact time problems which are intrinsic to adsorption and therefore to all GAC adsorption systems**.**

This is fundamentally important. It says that the very large (and expensive) GAC filters required for effective adsorption – involving multiple tons of activated carbon – are not necessary with ion exchange and are therefore not required in our Rocky Hill system design. **This is all discussed in detail in Section 1**. This is basic Physics. It is not conjecture or opinion.

The only remaining fundamental question was then --- is ion exchange good enough at doing this job? In other words **does ion exchange have the needed high efficiency and capacity to capture PFAS contaminant molecules in real-world municipal water facility operations?**

This crucial question is discussed at length in **Section 2** which relates directly to a recent very detailed two year pilot study conducted on this issue of PFAS capture by ion exchange resin which was carried out in Horsham Pennsylvania with an aquifer situation very similar to Rocky Hill, and which is specifically analyzed in the subsection:
Analysis of the Horsham study and relevance to Rocky Hill - Section 2 page 9.

The answer, from the Horsham data, is a resounding **YES, IT DOES.**
Not only that, the ion exchange resin **totally removed all PFAS contaminants** - including the very soluble PFAS members (such as PFBS) that GAC has trouble dealing with.

The Horsham study was not published in a major web publication, and largely escaped attention. It was only on reading the article and analyzing their data that the full impact became obvious. As mentioned in Section 2 page 1, the results were quite staggering. They had basically used ion exchange by itself (removing GAC filters) and documented **total PFAS removal** for over nearly 2 years, and with very detailed testing for 7 PFAS chemicals. No such data were previously available at this level of detail. This was the vital information that was finally needed.

They established quite clearly that ion exchange resins could now be produced with extremely high efficiency for ion capture of all PFAS contaminants with input levels of total PFAS varying between 60 to an average 100 ppt (parts per trillion) for nearly two years, and while using only 20 cu ft of resin overall.
The ion exchange capacity for PFAS capture was comparable to, and even exceeding, the capture capacity of GAC, - always considered the gold standard (for adsorption).

This was no typical pilot study with a resin column in a laboratory at low water flow rates, but was a study with a working municipal well pumping 50 gallons per minute continuously from a contaminated aquifer.
The resin eliminated **all of the PFAS members**, including the most water soluble ones such as PFBS.
[GAC has difficulty in adsorption of very soluble contaminants – as explained in **Section 1 page 4.**]

The optimum preferred method of PFAS removal is now clearly the use of PFAS selective ion exchange resin.
There should therefore not be any serious consideration of Activated Carbon being an acceptable method of eliminating PFAS in Rocky Hill water in view of the Horsham experience with PFAS selective ion exchange resin.

It is quite disconcerting to realize that none on the Council have commented in any way whatsoever on the submitted Rocky Hill design proposal and have not even admitted to reading any of the subject matter on the situation and the material content posted on the website.
The very favorable responses to the website information have been entirely from Community residents.

That was when it was suggested that something really useful for Rocky Hill would be to contact Horsham and set up some communication with them.
Actually this idea originated from a Borough resident who suggested that the next logical and conclusive step to be taken was to contact Horsham to remove any lingering doubts on the matter, and to confirm that their system worked well.

In response to the statement that we needed to design our own system, and that this was not the task or responsibility to be given to some unknowing contractor, it was implied that the Council as a whole could not handle something like that, nor could the borough engineer.

It was explained that this had all been done before. In the 1980's nobody knew how to remove TCE other than by adsorption using many tons of activated carbon – exactly the same scenario that is being replayed again right now (37 years later). There were system proposals presented to Council and to the Rocky Hill Community that varied from the impractical to the ludicrous. The main GAC proposal (with Union Carbide at that time) was extremely expensive (similar to todays GAC mega-dollar proposals).

[An addendum is added in this e-mail in the form of a quotation presented to Tom Decker for a recent GAC system proposal for Rocky Hill on October 13th 2020.
It is seen from this what the involved size and costs really are when using GAC filters to remove PFAS contamination. The quotation was forwarded by the Mayor for review, with thoughts and comments.]

Rocky Hill then, as now, could not afford mega-dollar projects, so it seemed inevitable that the only solution in 1982 was to pay for Elizabethtown Water Company to supply Rocky Hill with water. They offered to remove the water tower for free.
Fortunately there was such vocal opposition to Elizabethtown water quality that the Council finally decided to go ahead with the Ivor Taylor proposal to form a task force with him and design our own system based on aeration - which very few really understood fully. At least it was relatively inexpensive. There were some residents who had followed all the presentations and meetings and had discussed the issues and considered the science to be solid and that the project was a "no-brainer". They, and others, realized that the Water Facility was a major revenue generator that should not be lost, and that it could itself pay for the proposed aeration system fairly quickly (as it did).

Adsorption in Carbon was the wrong approach from the point of view of basic Physics when attempting to remove volatile organic contamination from water. The best and simplest approach was to take advantage of the volatility of the contaminants, and use aeration as an extraction technique.

The apparent present reticence to even read or consider the ion exchange design proposal presented on the www.rockyhillwater2020 website, and to brand the website as "fake news" – with no reaction or response from Council - is rather depressing.

If one was at all paranoid it might appear that the scenario of required needs for increased Capacity involving drilling for new wells and megadollar projects running pipework across the Borough to the existing Water Facility, and the need for installing a GAC adsorption system at additional megadollar cost for PFAS removal, and the additional expenses of system upgrading together with all the related Borough infrastructure expense problems, is perhaps painting a very bleak and hopeless picture to indicate and suggest the problems are now quite overwhelming

and the only solution is therefore to sell off the water system and go over to American Water Company. They will then come in and solve all our problems for us.

If there is any validity at all to this scenario not only would it be reprehensible, it would only re-enforce a perceived malaise that was described and covered in the original Situation Analysis presented on the website in early September.

It goes directly to the mentality that, in reality, we (Rocky Hill) feel incapable of deciding and doing anything ourselves and in this case, like perhaps in many others, must need some contractor persons to come along, tell us what to do, and do it for us (sometimes not very well). We seem to have (again) lost the involvement, and the pragmatic approach needed for problem solving. Everything is required to be a "turnkey" operation with somebody to be held responsible, whatever that means in practice. That was also how it started out in the 1980's, so it is nothing new.

This PFAS problem is obviously not something that can be made into an assigned problem for the Borough Engineer or for a Council member to solve. It is not as simple as that.
It is neither reasonable nor fair to expect the Borough Engineer to design a special system for Rocky Hill to eliminate the PFAS contamination. That task is beyond his individual experience and also is not his job - that is not what he does.
He can obtain quotations and suggestions from engineering firms that handle such problems, but not critically review the science and judge and evaluate the many new technical proposals for PFAS removal (and there are many – including things such as liquid plasma discharge for example from Battelle.) Most of these however are far from being viable scalable processes, which is what we actually need right now.
By extension it is also obviously beyond the capability of Council members, individually or collectively, to design or create a special PFAS removal system for Rocky Hill. Where would they begin? Undirected and unfocussed "research" of PFAS contamination problems is going to be overwhelming for anyone and is not going to lead very far. This is also the roadblock encountered by ad-hoc discussion groups, however well intentioned. That however does not mean the issue cannot be handled. It is basically a matter of approach.

The only accepted approach to a difficult project task (regardless of its size and importance) is through a directed and dedicated task force, treating the project as an important sole task mission. It is then treated collectively as a problem that has to be investigated and solved in all aspects. There is then involvement and effort and action, not just discussion.
This is not suggesting that there is lack of experience and understanding. Rocky Hill has actually been through all of this before. It is exactly déjà vu, all over again.

Adsorption using Granular Activated Carbon was the wrong way to optimally remove volatile organic contaminants in the 1980's – the best method was to take advantage of their vapor pressure and to use aeration - and similarly the use of GAC adsorption is not the best way to remove water soluble PFAS contaminants today.

As explained in Section 1 page 4, at the interface of carbon and water there is competition between adsorption (Van der Waals forces) and solubility (the bonding forces to the water molecules). The Van der Waals molecular forces are weak and very soluble molecules or dissolved salts are therefore not adsorbed. The PFAS molecules are themselves water soluble and the more water soluble ones, such as PFBS and Gen-X, are the troublesome ones that are present in groundwater and assimilated into the food chain through vegetables and fruit. They are not adsorbed by GAC very effectively.
That is becoming an increasingly appreciated problem.

In Section 1 page 6, it is explained that we need some other approach than GAC to optimally remove PFAS. This introduces ion exchange, in Section 1 page 7.
Ion exchange has the tremendous advantage of being a completely different process to adsorption, and one that avoids the practical problems of contact time (EBCT) needed with GAC as a result of the short-range molecular forces that are acting in adsorption.
It is this EBCT requirement that causes the need for such enormous amounts of GAC in GAC adsorption filters, and which are not needed with ion exchange.
So, basic Physics is beginning to provide us with an alternative approach.

This approach is not yet fully determined however because the effect of background dissolved organic matter (DOM) is not evaluated. Since it is dissolved in water DOM is also ionized and so becomes a major player in ion exchange. The problem with GAC becoming easily "saturated" with adsorption of all sorts of background molecules could then become equally applicable to some degree with ion exchange becoming smothered by the background of dissolved organic material (DOM) ions.

This question was studied by a Canadian group at University of British Columbia, Vancouver, and published online in June 2020 (Dixit. et al.) - so it is very recent information. They used a Purolite ion exchange resin (A860) for PFAS extraction. This is discussed in Section 3, page 2. They studied the removal of PFAS contamination in river waters with various DOM levels.
They found a very serious effect of DOM on ion exchange efficiency, so that it is essential that the residual DOM content be kept low to get high PFAS extraction efficiency.
However, they were dealing with river waters with DOM levels in the parts per million (mg/liter) and they found that going from 20mg/L down to 2.5mg/L there were big improvements in their measurements of bed volume (BV) to breakthrough.

The DOM concentration in aquifer water (such as Rocky Hill) is generally much lower than in river water, from parts per million down to parts per billion.
The Dixit study indicated very good PFAS extraction results for systems with low DOM levels. Their lowest DOM level was 2.5mg/L (or 2.5 ppm, 2500 ppb).
Typical aquifer DOM levels would be much lower, around 200 ppb.
Most importantly, their data indicated **total removal of all PFAS contaminants by the ion exchange resin**.

Since the Rocky Hill water system uses aeration (and aeration is a method of removing DOM – see Section 3 page 3) we can insert our ion exchange filters in the aeration stages to get minimum levels of DOM into the ion exchange filters.
So now things were beginning to take overall shape more clearly.

Ideally we still needed a study much closer to our Rocky Hill aquifer situation, and one that could actually provide PFAS extraction data of sufficient detail to be able to generate a system design with some level of confidence.
Fortunately this was already being done by the Water Authority at Horsham Pa.
Under pressure to solve a bad PFAS contamination problem in their water supplies they had initiated a pilot study from Nov 2016 to Aug 2018 with ion exchange resin.

The Horsham pilot program was an expensive and detailed study conducted over nearly two years involving daily laboratory testing of 7 PFAS contaminants.
This is described fully in **Section 2.** It was the needed "clincher" to the story.

The Borough Council and the Rocky Hill Community have got to come together and face up to the reality of the PFAS situation in Rocky Hill in this coming year 2021.

Occam's razor implies that the simplest and most practical solution to a problem is the best one - and is also in most cases the least expensive one.
There is something inherently unsatisfactory in having to consider and involve million dollar expenditures to remove only a few trillionths of a contaminant. That in itself provides motivation for finding alternative pragmatic solutions.

In our particular PFAS situation the fundamental question becomes –- what external contractor is going to design and provide a Rocky Hill system for PFAS removal anything like the specific low-cost one that is developed and presented in Section 3 on the www.rockyhillwater2020 website?

It is now quite apparent that the obvious contractor responses will be to quote a GAC megadollar project just like the one that has recently been quoted to Tom Decker the Borough Engineer in October (presented in the Addendum). At the present time they do not know how to do anything else. There is minimal contractor experience with ion exchange. It is a new technology for them in this type of situation.

In reality, the situation before Rocky Hill is totally favorable.
As described, the system is already researched and designed, and all the details are fully described and it uses standard commercial components, so there is nothing to be specially made or developed. There are no difficult or intractable problems.
Additionally (**and most important of all**) it has been done already.
This is absolutely invaluable, and that is why talking to Horsham should be an obvious first priority – if only to dispel any possible lingering doubts and fears that might still persist somewhere. **It has all been done already.**

What is presented in **Section 3** is a trivial project. The only thing seriously approaching "engineering" is the design of the needed extension building that requires some thought and planning and architectural advice in this case.

There are logistical requirements in the moving around and location of the resin filters, that are of manageable size (4ft diameter, 6ft height) but cumbersome. This should be an operation only required every 4 (or more) years, but needs to be planned and tested as a standard routine. We need a ceiling height of at least 10 feet for adequate working room. This however should not be a major problem.

[One can only imagine having 15 ft high, 11 ft diameter "vessels" loaded with tons of GAC and located inside a required building to be disconnected and moved around every 3 years - which is implied as being a needed requirement in the AdEdge GAC proposal in the Addendum.]

The Borough Engineer would be more than capable of overseeing and directing all aspects of construction phase in the project described, which would of course be fully planned and documented by the task force. The Borough is more than capable enough to "handle" this project - just like any other job. Yes we can.

Ivor Taylor. Jan 21 2021.

<u>Addendum.</u>

The following describes a GAC (Granular Activated Carbon) adsorption system proposal for Rocky Hill submitted to Tom Decker (Rocky Hill Borough Engineer) by Chris Savino of AdEdge Water Technologies on Oct 13th 2020.
The main relevant items of the quotation are:

* 10 minutes of contact time required with carbon media
* Two (2) 11ft diameter, 15ft tall vessels required (approx. $500,000 for equipment)
* Vessels need to be housed in climate controlled building approximately 30ftx30ft footprint. ---- needed.
* Photo of two 10ft diameter vessels (next page) is provided by AdEdge – the vessels shown are located in an outdoor installation in California.
* The media needs to be swapped out every 3 years (approx. $100,000 per swap.)
* System is backwashed each time new material is installed and every 60 days of operation.
* Backwashing requires 800-900 GPM flow rate for 10 minutes each vessel (i.e. 16,000 to 18,000 gallons total).
* A holding tank is required to temporarily store the backwash for disposal.

* The existing (Rocky Hill) well does not have the capability to backwash the system without additional pressurization.

General observations

This is not a formal quotation, and therefore many necessary specifics are not itemized, for example:

* Does the cost of $500,000 for equipment refer to just the external hardware as shown in the photograph? – what is the cost of the GAC media for both vessels?

* Also, is this $500,000 the cost for purchase or just for the installation of the vessels and the system hardware? Are there additional ongoing rental fees for the vessels?

* Does "$100,000 per swap" relate to media for one, or for both vessels at the same time?

* Is this system based on lead-lag operation? If not, how is the system down-time going to be handled when both vessels are being re-loaded with GAC?

* How are the vessels emptied and re-loaded with new GAC ? Are they physically removed and flat-bed-trucked off site? What are the service charges for such GAC handling and replacement and for vessel re-installation every 3 years?

Tom Decker was just trying to get a general representative quotation but, as we can see already, the devil lies in the details.

By contrast, in our Rocky Hill system design (Section 3) using ion exchange, there are two filter units of 4ft diameter, 6ft height, costing $9000 total with 1000 liters of Purolite ion exchange resin in each, costing $16,000 total. The total filter system cost is then $25,000.

The two filter units are operated in alternating lead-lag configuration.
A resin replacement for one unit (1000 liters) is needed every 4 years (hopefully longer) at a cost of $8,000, which includes Purolite Inc. taking away the used resin.
We would load the new resin ourselves, on site.
There are no backwash operations required with the use of the resin.

The following photograph of GAC vessels is by courtesy of AdEdge Water Technologies.