## Controlled Drainage Logistics

## Season 1, Episode 6

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**John McMaine:** Thanks for joining us on Streamlines, your source for water knowledge. I’m your host, John McMaine, with South Dakota State University Extension. This is Episode 6.

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**John McMaine:** Let’s talk about control drainage today.

**Anthony Bly:** Sure.

**John McMaine:** And we’re going to bring in Matt Helmers.

**Matt Helmers:** Matt Helmers, director of the Iowa Nutrient Research Center at Iowa State University.

**John McMaine:** Matt’s working on a project, among many things. One of the projects Matt’s on is the transforming drainage project. And one of the practices of the transforming drainage project, is something called control drainage. You’re familiar with control drainage, right?

**Anthony Bly:** Absolutely.

**John McMaine:** Yeah. And so, you’ve seen the control structures and-

**Anthony Bly:** Those little mini dams you put in.

**John McMaine:** Exactly! Yeah, so you’re basically damming up the water in a tile system.

**Anthony Bly:** Holding it back.

**John McMaine:** Holding it back, yeah. To keep it when you don’t need drainage or you know, hold it anytime it rains or whatever.

**Anthony Bly:** And your field operations are done.

**John McMaine:** And exactly, when your field operations are done, it’s a great way to hold water back.

**Anthony Bly:** Yeah.

**John McMaine:** We talked to Matt, and he identified two big reasons that we would consider control drainage.

**Matt Helmers:** Probably two reasons. One is, you know, there are increasing concerns about nitrate export from our tile drain lands. And we have found that controlled drainage can help us reduce that direct tile discharge and nitrate loss to the stream. Also, it may hold back some water that in certain conditions, it would probably be kind of idealized conditions, but certain conditions might provide water for the cropping system in the field.

**John McMaine:** So, yeah. Nitrate load reduction.

**Anthony Bly:** Sure.

**John McMaine:** And-

**Anthony Bly:** Water conservation.

**John McMaine:** Water conservation. So, if you’re a producer, you are a producer. Why am I saying ‘if you were.’ You are a producer.

**Anthony Bly:** I know a lot of producers who say that.

**John McMaine:** Well, you are a producer too, Anthony.

**Anthony Bly:** A small one.

**John McMaine:** Fair enough, fair enough. So, I know water is one of the biggest things really either too much or too little.

**Anthony Bly:** Absolutely.

**John McMaine:** And one of the ways that we deal with too much is through tiles.

**Anthony Bly:** Yeah. Get rid of it so we can traffic our fields.

**John McMaine:** You can traffic your fields, so you don’t drown your roots out. But how many years have you had a field that is too wet in the spring and is too dry in the summer?

**Anthony Bly:** At the same time, very very rarely.

**John McMaine:** Okay.

**Anthony Bly:** But it, but it, but it does happen.

**John McMaine:** What about, say, back-to-back years? Or, I mean, would you have a wet spring one year and a dry summer the next year?

**Anthony Bly:** Yes, that can happen.

**John McMaine:** So, control drainage gives us a little more flexibility on that drainage system. Those control structures, they act as a dam, like you said. And you can hold water back.

**Anthony Bly:** Absolutely. I love, I love the concept because that water that we get is a gift.

**John McMaine:** It’s a resource, absolutely.

**Anthony Bly:** It’s a resource, it’s free. And then we see it go away. And it’s like, wow, what could we have done with that?

**John McMaine:** Yeah, so control drainage is one way you can think about that differently.

**Matt Helmers:** So, the primary way that it is helping to improve water quality is to reduce direct drainage discharge. So, we are working on a synthesis paper, it’s looking at the impact of control drainage across the corn belt. We don’t find a change in the concentration of nitrate coming out of that drainage water. But what we are doing is we are holding some of that water back. And as a result, the nitrate load going downstream, if the concentration doesn’t change, but if the water flow goes down, are, you know, pounds per acre of nitrate delivered going down.

**John McMaine:** Excellent. So, how does it perform? How well do we reduce nitrate?

**Matt Helmers:** So, it depends, I guess. It depends where we’re at, any given year. For one of our sites, down in Southeast Iowa, we’re seeing about a 40-50% reduction in nitrate load in going downstream. And one of the things that we’re finding as we’re looking across the corn belt, over a variety of years is we see similar, kind of, inches of flow reduction. No matter if it is a dry, wet, or normal year or average year. And so, you know, I think that it helps us in any kind of year. On a percentage base, it is probably going to help us more in a dry year than a wet year. But on an absolute kind of flow reduction, you know, inches of flow reduction, pounds per acre of nitrate loss reduction. It’s pretty similar across all those types of precipitation pattern years.

**John McMaine:** So that’s something really interesting to me because I would think there would be a difference, right? But it seems like the control drainage system pretty much has the capacity and once it reaches that capacity, and that capacity can be reached in a dry year, once it reaches that, you know, that’s how it’s going to perform.

**Anthony Bly:** Absolutely.

**John McMaine:** So...

**Anthony Bly:** Yeah, and it’s pretty universe.

**John McMaine:** Yeah, that’s a fair point. And the other thing is, a lot of times we get hung up on concentration. Right? I mean, we will measure concentration out on a tile or in a stream or in a river. I mean, that’s what, I think that’s driven because that’s what the drinking water standard is. You got to hit 10 parts per million for it to be legal drinking water. But concentration is only half the story when we look at drainage systems.

**Anthony Bly:** Because it’s the load.

**John McMaine:** Because it’s the load that we care about. And we don’t put nitrate on or nitrogen on any concentration. We put pounds of whatever on, right.

**Anthony Bly:** In an amount.

**John McMaine:** In an amount. And so, controlled drainage, it doesn’t do anything for us for concentration. But the way it helps us is it reduces that flow. And by reducing that flow, we reduce the load.

**Anthony Bly:** And less goes out.

**John McMaine:** Less goes out. So, one of the questions I asked Matt was, you know, how does control drainage perform from East to West. And there is a really pretty significant precipitation gradient and as we go North, there is a temperature gradient obviously. And, one of the things that he talked about was kind of the timing during the year of when we lose nitrogen, as well as the timing of when control drainage is most effective, when we are seeing those reductions.

**Matt Helmers:** So, one of things is when we started looking at the studies across the region, we expected to see some differences in overall load reduction. We’ve not seen as much of that, but we’ve seen a change in when that load reduction occurs. So, in the eastern part of the corn belt, Ohio Indiana, we see more of the drainage in some the winter months, late fall into winter and we call winter January, February, March. And so, they’re getting a lot of their load from the drainage system and then, ultimately load reduction with controlled drainage in those winter months. Whereas, in South Dakota, Southern Minnesota, Iowa, we are getting more load in the spring but more of the flow reduction in the spring, just because that’s when it’s happening. So, as we look across the corn belt, they perform pretty reasonably and similarly across there. But we did see the timing change with more load and load reduction in winter months in the East. More load and then load reduction with control drainage as we move to the West and North part of the corn belt.

**John McMaine:** To me, I’d say that means there’s a lot of opportunities for control drainage in especially in maybe more milder climates. And to me, it presents a little bit of a challenge. Because the closer we get to planting, the sooner you want to pull those boards, right?

**Anthony Bly:** Right.

**John McMaine:** And so that potentially creates a challenge. Because we are fighting two things: we’re fighting nitrogen loss as the ground warms up and thaws out and those tiles are running, but then we are also fighting being able to get in the field.

**Anthony Bly:** Field, do our work.

**John McMaine:** Yeah, do the work and get your seed in the ground. And so, it is still a practice that I think can benefit water quality in South Dakota, but it may be not as straightforward as if we’re in Indiana.

**Anthony Bly:** Well, we’re limited by water. So, water conservation, I think, would be good in some of those years.

**John McMaine:** That’s absolutely right. And we’ll see what Matt has to say about kind of the yield aspects and if there’s any potential benefits there.

**Matt Helmers:** I think it’s pretty economical. You know, if we have field sites that are pretty flat, if we don’t need a lot of control structures, I think it can be pretty economical because, really, the extra cost is in the control structures. Now, you might have a little bit, you know, we’re going to lay our tiles along the contour a little more, so you might have a little bit more tile or maybe a little bit more installation cost there. But I think it can be a pretty economical type of system, maybe in line with some of the things like saturated buffers, bioreactors, even wetlands. Kind of depending on the system. And I would just encourage, you know, any producer that’s thinking about drainage, try to design it and install it with controlled drainage in mind. So, you might not put it in now, but if you design for that in mind, it’ll be easier to retrofit it in the future. So that’s putting our laterals a little more along the contour, maybe running the main up and down the slope a little, a little bit more.

**Anthony Bly:** So, this can, can this work with targeted drainage? Because I think Matt is really referring to more of a grid pattern or overall drainage of the whole landscape.

**John McMaine:** Like, he’s referring to pattern tiling versus targeted tiling.

**Anthony Bly:** Right, right. South Dakota has mostly targeted drainage.

**John McMaine:** Yeah.

**Anthony Bly:** Where there’s an issue and a problem in a certain area of the field. And you just go, go after that.

**John McMaine:** Yeah, you know Anthony, that’s a really good question. And I think, it can work for targeted tiling. The question is, the slope. So if you’re going up, you know, a significant slope change, like one of your fields is pretty steep, right?

**Anthony Bly:** Absolutely.

**John McMaine:** Yeah, I mean it’s what, 10 or 15 or 20 feet from top to bottom?

**Anthony Bly:** Oh, it’s more like 75 or 80.

**John McMaine:** Oh okay. I was way out there. So okay. 75 or 80 feet, then you know, you’d have to put in 40 control structures.

**Anthony Bly:** Right.

**John McMaine:** If you were going to control the whole field with that.

**Anthony Bly:** Right. Kind of cost prohibitive.

**John McMaine:** That’s very cost prohibitive, yeah. And so, I think that’s the biggest question about whether it could work. You know, pattern tiling or targeted tiling… what’s the slope, what’s the difference in elevation going to be, and how much land you can control with each control structure. Another thing I asked Matt about is kind of what he sees is the future. Like, what should we get excited about for control drainage?

**Matt Helmers:** I think if, maybe a couple things, you know. I think that there is some work with water gauge structures that are kind of buried. Looking at those and their longevity and how they work. I think it is important because then you might not have as many structures coming out of the ground in a field. You know, I think there is a lot of interest in automated management. You know, or automated systems so that it’s on your smart phone. You tell it to raise or lower the gates, so you don’t have to go out there and do it. Or if there’s a rain coming, you can easily raise the gates to allow a little bit more storage capacity in the soil. I think that’s, I think those are aspects that would help the adoption in a way or maybe help the management of that. So you know, it’s not just kind of set it and forget it, and then you could run into some problems if you aren’t, aren’t managing it during the wet times of the year, when maybe you want to pull some of the plates. So, I think that, thinking about some of the modern technology of control structures might be useful as we move forward.

**John McMaine:** One of the things Matt talked about was automation.

**Anthony Bly:** Yes.

**John McMaine:** And this is something that just really really gets me excited. Thinking about precision agriculture and potentially precision drainage, really?

**Anthony Bly:** Right.

**John McMaine:** I mean you could have a field, if it was targeted tiling, then you could, you know, manage that daily if you wanted to. Not that you would need to, because it’s not going to flow or make that much difference. But just the ability to completely manage the water table in that field with automated control structures.

**Anthony Bly:** Knowing where the water tables at would be a big thing.

**John McMaine:** Yeah, and so, I think to me, there are commercial systems that you can do automated control drainage. But to me, the next steps would be in the data that you are collecting and how you are incorporating that data into management decisions. If we think about corn or beans, or really any crop, it’s going to, the amount of water it uses is going to change throughout the year. So really the value of water, in a sense, changes throughout the year.

**Anthony Bly:** Absolutely, it goes up and down.

**John McMaine:** And because of that, you would change how you manage. You know, you might want really high boards, a high elevation, for your outlet in the summertime when you’re very dry and your corns using a lot of water. You might want a very low one in the spring when your crops just getting started. And so, building data collection and precision agriculture technologies, soil moisture, potentially short-term forecasting, getting an estimation of ET rates from that crop. I mean, all of those could come together to-

**Anthony Bly:** Tell you where your water levels should be.

**John McMaine:** Exactly.

**Anthony Bly:** Yeah.

**John McMaine:** So, that’s something that gets me really excited.

**Anthony Bly:** Yeah, that’s awesome.

**John McMaine:** Maybe if you could talk specifically about what you’re doing to advance the science or outreach or any aspect of control drainage.

**Matt Helmers:** Yeah, so we, we’re going on about 10, 12 years of control drainage research at our southeast research farm. We have consistently seen nitrate reduction with that. We do a lot, or a fair amount, of education around drainage design. We have a drainage school in Iowa, or at least we did until 2020 with COVID. And really try to talk about, you know, how we can design this for control drainage in mind for the future. Try to do that with some other extension and outreach type of events. We have some, some of the work that is kind of ongoing as well at our southeast research farm and then we are going to do some new work with some other drain spacing and depth work is to look at how does control drainage or maybe if we put the drains in a little shallower, which is almost like a year-round control drainage, how might that impact fertilizer use. You know, nitrogen, kind of optimal nitrogen rates, and how might that compare to areas where maybe we don’t have any drainage at all. Mike Castellano at Iowa State is leading a lot of these efforts but trying to combine some of the water quality aspects, you know water outflow aspects, with some of the nitrogen use sufficiency aspects as well. And so, kind of how do we optimize drainage design or management with controlled drainage to enhance crop production and make the best use of the fertilizer that we are putting on as possible.

**Anthony Bly:** Interesting concept: combining it with nutrient deficiency.

**John McMaine:** Yeah. How do you think that would change things?

**Anthony Bly:** Well, you know water, water and nitrate work together. I mean, without water, nitrate efficiency or nitrogen use efficiency goes down. So having the right amount of water there is going to increase the nitrogen use efficiency of that crop.

**John McMaine:** That’s very true.

**Anthony Bly:** So, if you can partner those together for optimal level, that should be a good thing.

**John McMaine:** Yeah.

**Anthony Bly:** You know, we all want to see our nitrogen use efficiencies down to .7 or .8. I’m sure this year, or in some parts of our fields where it was very dry, our efficiencies were very poor because we did not have enough water.

**John McMaine:** Yeah, maybe it doesn’t just improve the water availability, but water availability affects a lot of other factors.

**Anthony Bly:** Absolutely! I mean, it’s the, you know, law of the minimum and water’s apart of that.

**John McMaine:** Sure. Makes sense.

**Anthony Bly:** I would just be concerned with where do you put that water table at?

**John McMaine:** If you’re doing shallow?

**Anthony Bly:** Yes. With regard to the, to where the roots are at and the stage of the crop. Because we know reproductive stages on corn have a root system that can go very deep versus younger corn, you know, they’re more shallow.

**John McMaine:** Sure.

**Anthony Bly:** Do you move that water table down as those roots want to go down? And encourage that? Or do you try to grow a crop that’s only got roots in the top two feet?

**John McMaine:** Oh yeah. I’d say the first one would be my guess. Or that would be my preference, I guess. But there’s a big gap between where we’re at now and the availability to do that.

**Anthony Bly:** Yeah. The knowledge for where do you do that.

**John McMaine:** Yeah, so, should we use control drainage?

**Matt Helmers:** Should we use control drainage?

**John McMaine:** Should we use control drainage.

**Matt Helmers:** I think that we should use control drainage in places where, where site suitability seems most conducive for, for control drainage. I think we want to use it in pretty, pretty flat fields. We have done a little work with modeling and with some very small scale lysimeters that when we do have that higher water table, there might be a little more surface runoff. So, I think having pretty flat fields, where even if we got a little surface runoff, it’s not maybe as critical or detrimental. Also, those flatter fields are going to work better for having fewer structures. So that you might be able to manage 30 acres with one structure, I think then it becomes a little more economical and easier for the farmer to manage. You know, there is one other research aspect that I think we do need to still ponder with controlled drainage. And that’s where does the water go? You know, if it’s not coming out of the tile line, where does it go and making sure that that’s not a nitrate problem. I think a little might go to surface runoff, a little bit more might go to deep seepage. But we would expect maybe some greater opportunity for denitrification as the water moves through those slower pathways. So, I think control drainage can be good, but I think site suitable might limit the applicability in certain areas.

**Anthony Bly:** There you have it.

**John McMaine:** There you have it. It’s a good practice. It, you know, does a good job of reducing nitrate loads by holding that water back. But it’s one tool in the toolbox, right? It’s not going to fit everywhere.

**Anthony Bly:** Can you combine it with all the other tools? And then you got to apply the right one in the right situation.

**John McMaine:** Right. So, yeah. Jeff Strock great guys. Worked in drainage, 20+ years and anyways, this is what he had to say about control drainage.

**Jeff Strock:** So, one of the things that we have found over many years of working with controlled drainage or drainage water management, is that it’s been portrayed as kind of a win-win situation. So, it’s a win for farmers in terms of thinking about crop yields and water quality. We always have not seen this, this yield benefit in a year in year out basis. But every year that we have implemented this practice, we do see water quality benefits. The main way, generally speaking, is the reduction in the drain outflow. Less water leaving the system, compared to say, a free drainage type of a system. So, less water leaving the system, retains with it then in the soil profile the dissolved nitrogen or phosphorus which may exit the system when we would normally have drain flow. So, we always have had water quality benefits with controlled drainage. We just haven’t always seen those yield benefits.

**Anthony Bly:** So, a producer can really, you know, do some math and show maybe a return on that investment and that control drainage water system.

**John McMaine:** Yeah. Absolutely. I mean it can be a win-win. Not every year like he said, but certainly there are years that controlled drainage is going to outperform conventional free drainage.

**Anthony Bly:** And then at the same time, the reduction in nitrate load is a benefit as well. Back to the economics of growing a corn crop. But shows they’re doing something.

**John McMaine:** Yeah, that’s a good point Anthony. And, I mean, being able to manage water, really is certainly can have benefits to yield. But if it’s not very well managed, that can be a double-edged sword.

**Jeff Strock:** It’s really about an interesting kind of journey. We did our research in a farmer’s field and so we were using very large field scale areas. And, you know, one of things that we found was is that mother nature is in control. So, if she provides the water that we have to manage in the drainage system to conserve water, it can be advantageous. If we don’t have water to store and say we get a dry period in a given year, and we haven’t stored any extra water, then you can have these years where you don’t see a positive yield impact. We also have seen some years where we get very wet years and if we don’t manage the drainage system properly, we can actually end up seeing yield losses in fields where we’ve managed with controlled drainage because we end up actually having excess water in the soil profile. And that can certainly have a negative impact on soil aeration and the oxygen available into the roots and that can kind of reduce our yield in those years as well. You know, at the end of the day, water is the driving force in the systems. Whether they work or they don’t work for water quality and for yield, and again, generally what we have found is, is that if we have got water stored in our system and we get a short-term dry period during a growing season it can be advantageous for yield. If we get into a severe drought, which we have had over the 15, 18 years that we did this research, you know, control drainage does not help us during these really severe droughts. You know, there’s just no water to be had and manage at those times.

**Anthony Bly:** Yeah, we were talking about that before, you know. How high do you keep that water table and when do you keep it there and for how long?

**John McMaine:** Yeah. I think that’s why automation, I see, is one of the big potential exciting things about the future of control drainage. Because you can take all of that into account and make kind of on-the-fly changes to optimize the water availability without getting too much water. And kind of the paradigm, controlled drainage has been maybe three different outlet elevations. Okay, you have one where you drop it to conventional drainage in the spring. You know you want your drainage system to be functioning as it should. And then after you’ve planted, after you’ve done field work, you raise it a little bit. Not enough to drown those roots out, but enough.

**Anthony Bly:** Start storage.

**John McMaine:** Start storage, exactly. So, if you get it in time it rains, you can take advantage of those. And then the third is maybe after harvest. So, after you’ve done your fill work in the fall. Now you can raise the boards all the way up, as high as you want really, to hold the water over the winter and into the spring. But that really has limitations. Both for getting too much water, I mean we could potentially drown our plants out and need drainage.

**Anthony Bly:** Absolutely. You get, you get one of those high make it rain events and you’re in trouble.

**John McMaine:** And so, Jeff really emphasizes the need for active drainage which hasn’t been a current paradigm and is really kind of challenging under the current technology that is out there. But that gives the most advantage for yield potential and for water quality.

**Anthony Bly:** It’s like managing an irrigation system.

**John McMaine:** It really is like managing an irrigation system. That’s a good metaphor, Anthony. So, Jeff brought up a really interesting point about possibly in the future using something like a nitrate sensor.

**Jeff Strock:** You know as we move into the future and we think about these things, we might also be able to as the sensing technology comes online and perhaps gets less expensive, maybe we’ll be able to use dynamic nitrogen sensors in these systems as well to help inform us should we be letting water loose, should we not be letting water loose. And in terms of not only thinking about water, but also nutrient available in that water for the crop. But also, you know, what we might be releasing downstream.

**John McMaine:** Really, I mean, it comes down to what information do we have to make a decision about where we set the gate.

**Anthony Bly:** Yeah, right now I think there’s a lot of just by your bootstraps, you know. You feel like you should put a gate in or take one out based upon how wet it’s been and how dry it’s going to be or maybe the opposite and we really need a lot more information to guide us in those steps.

**John McMaine:** So, so this is how precision ag in a lot of ways can also offer answers and solutions and really information that we need to make decisions about water too.

**Anthony Bly:** Yeah, we have those water, you know, those water probes, that we can put in. Those moisture probes in the soil and yeah, I think it’s coming, I think it could be there pretty soon.

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**John McMaine:** Thanks for joining us for another episode of Streamlines, your source for water knowledge. Be sure to turn in next week for Part 2! If you want to learn more about anything you heard today, head on over to the SDSU extension website, but for now, I’m John McMaine.

**Anthony Bly:** I’m Anthony Bly.

**John McMaine:** And we’ll catch you next time.