Altered Watercourse Identification using GIS
A Pilot Project

Final Report

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1.0 Project Summary

The purpose of this pilot project was to develop and test a methodology to distinguish between natural and altered watercourses and to represent that determination as a 'natural/altered watercourse' event tied to the high-resolution National Hydrography Dataset (NHD).

This project was conducted in support of the MPCA's water quality monitoring and assessment activities. Specifically, the MPCA is proposing a tiered aquatic life use class system that will include a modified warm water class. Eligibility for this class will depend on an accurate state-wide determination of altered stream segments that will be consistent with and based upon the National Hydrography Dataset (NHD). This pilot project defined a method to create that determination. The NHD itself does distinguish between a 'canal/ditch' flow feature and unaltered features, but that data is out-of-date in some areas. MPCA asked LMIC to use other available GIS layers in additional to the NHD to devise an improved altered watercourse identification technique.

The MPCA requires that the determinations be referenced to the NHD because all of its water quality reporting to the USEPA is legally required to be based upon the NHD.

For this project, LMIC developed and documented a methodology and tested it on selected watersheds. LMIC used a new event creation tool, the Hydro Event Management (HEM) tool, developed by the Pacific Northwest Hydrography Framework group, to create the events using the ESRI ArcMap software. LMIC staff created an add-on to the HEM tool to make it easier to assign values and to collect additional information requested by the MPCA. An MPCA technical advisory committee provided feedback on the methodology. MPCA also provided ground-truthed information from a Stream Habitat Evaluation Area Site Assessment Database that provided a check on some of the determinations. MPCA requested an assessment of the amount of time it would take to complete the state using this method.

The Land Management Information Center entered into an Inter-Agency Agreement with the Minnesota Pollution Control Agency to undertake this pilot project in F.Y. 2008.

Major LMIC tasks that were outlined as part of this project included the following:

1. Select pilot areas for evaluation
2. Research, develop, and document a methodology
3. Test/modify event creation tools as necessary
4. Test methodology/create events/qc events
5. Write final report
6. Make selected updates to the NHD

Section 3 of this report describes the project tasks in detail.

2.0 Background

This project was conducted in support of the MPCA's water quality monitoring and assessment activities. MPCA is proposing a tiered aquatic life use class system that will include a modified warm water class. Eligibility for this class will depend on an accurate state-wide determination of altered stream segments that will be consistent with and based upon the National Hydrography Dataset (NHD). Because all of MPCA's water quality reporting to EPA is based on the NHD it was important that this determination was also based on the NHD.

MPCA initially looked at the National Hydrography Dataset (NHD) GIS Flowline layer to evaluate whether the NHD Feature Type (FTYPE) coding for 'stream/river' and 'canal/ditch' was adequate to be used to determine the miles of altered watercourses for their reporting purposes. They determined that the NHD was not adequate for this purpose. There are significant areas for which the NHD is out-of-date. The NHD Feature Type coding is based largely upon the hydrography representation on the 1:24,000-scale USGS topographic map series. MPCA determined that the FTYPE coding on the NHD Flowline feature – when compared with newer imagery – did not adequately represent the natural/altered watercourse feature. Often newer imagery indicated that the stream feature had been ditched since the original USGS quadrangle maps were created.

Initially MPCA and LMIC discussed changing the codes on the NHD to reflect the project's altered/natural determinations. However, this was deemed impractical for two reasons:

- The NHD Feature Type definitions have rules, and the rules for the assignment of a feature type of canal/ditch may not be exactly the same as the MPCA's determination rule for altered/natural. We cannot change the FTYPE based on a non-NHD feature definition rule.
- Even if it were legal to change the FTYPE on the NHD Flowline based on the Altered/Natural determination, as a practical matter it would be difficult. We would need to change the FTYPE code and modify the NHD linework to match the current ditching. To perform updates on this many NHD features would be time-consuming – and those changes would have to work their way through the NHD update process. This stood in the way of creating a timely 'altered watercourse' layer.

This process did identify some stream segments that needed to be redigitized to address their current ditched status: information about stream segments needing updating will be passed to the NHD updating team.

Once making all of these determinations directly on the NHD was eliminated as an option, LMIC and MPCA decided upon creating the 'Altered/Natural' determination as an event referenced to the NHD, using national tools developed for that purpose. The event referencing of altered watercourses is based on interpretation of auxiliary data, especially newer imagery. Defining the 'natural/altered watercourse' as an event on the NHD assures that this designation does not become a static layer, but can evolve with the NHD - through the reach migration process - if the NHD linework is updated.

3.0 Project Tasks

3.1 Select Pilot Areas for Evaluation

LMIC was asked to select pilot areas for evaluation in the subregions 0701, 0702, and 0703, (areas upstream of Lake Pepin), based on differing hydrologic characteristics or regimes that would enable us to develop a methodology that would cover the variety of hydrologic situations existing in Minnesota. To select the subbasins LMIC staff reviewed the hydrology of those areas using the National Hydrography Dataset (NHD) linework and FSA 2008 imagery for areas that looked different hydrologically. The choice of subbasins was somewhat subjective, but did result in three areas that differed in the amount of natural and altered watercourses and the level of difficulty in determining between them. The choices represented lower, medium, and higher levels of agricultural and ditching activity. For quality control purposes MPCA had made LMIC aware of a database of on-site assessments of altered and natural watercourses. LMIC made sure that the areas chosen had sufficient on-site assessments that we could use that database for quality control evaluation.

The following subbasins were chosen for evaluation in this pilot project:

3.1.1 Snake River – St. Croix Basin (07030004)

The Snake River subbasin is a more forested area with primarily unaltered streams, but it does have some areas that exhibit artificial drainage, and some areas where it is difficult to distinguish between altered and unaltered watercourses. The Snake River has 1,662.633 kilometers of watercourses represented as 'NHD Flowlines' in the high-resolution NHD.

3.1.2 North Fork Crow River (07010204)

The North Fork of the Crow River represented an area that was more agricultural than the Snake River, with more obvious ditching. The North Fork Crow River has 2,576.4 kilometers of watercourses represented as 'NHD Flowlines' in the high-resolution NHD.

3.1.3 Redwood River (07020006)

The Redwood River was chosen as an area that is heavily agricultural and heavily ditched. The Redwood River subbasin has 1,551.6 kilometers of watercourses represented as 'NHD Flowlines' in the high-resolution NHD.

3.2 Research and Develop Methodology

3.2.1 Methodology Task Specifications

LMIC was asked to research and develop a methodology that could be applied consistently across the state, by different users. The Scope of Work for the project asked that the methodology include at a minimum the following factors:

- Test in different areas of the state which have different hydrologic characteristics.
- Use a variety of background GIS data sources to help make the determination.
- In particular, base the determination on newest or best available imagery (e.g., 2003, 2006 FSA), rather than the current NHD linework or feature classification.
- Test differing methodologies. For example – will the overall determination differ depending on whether one starts at the headwaters or the downstream end of each watercourse?
- Change the designation only when there is reasonable evidence of a change on the landscape.
- Create a methodology for determining the upstream ends of stream segments. Stream headwaters segments need to be determined in a scientific and consistent manner across the state.
- Do not characterize any stream segment smaller than roughly 150 meters to help speed up the process. Ignore really small segments like rivers flowing through culverts under roads.
- Develop and populate attributes that help explain the decisions made:
    - A Data Confidence Code to indicate the level of confidence in the determination made.
    - A Comments field for additional clarification
    - A Field to indicate where the existing NHD linework is really different than the current imagery. This code could be used later to identify areas where the NHD linework needs to be updated – even though the NHD update itself will not be part of this project.

LMIC was also asked to test the methodology that was developed, as outlined in the Scope of Work:

- Create 'altered/non-altered' events on the NHD based on this methodology.
- Have different LMIC staff do determinations on the same area – see where they agree, where they disagree, resolve differences, modify methodology as necessary.
- Get feedback on the methodology – and the resulting determinations - from MPCA staff and from staff from other organizations.
- For a first-level quality control, compare determinations against areas where MPCA staff has made on-site determinations (stream habitat evaluation areas).
- Test methodology in some areas (Crow River) where MPCA will be doing field work and could possibly provide field verification.

MPCA agreed to set up advisory and information gathering meetings with MPCA and other state agencies to discuss the methodology used, the results of the pilot effort, and the feasibility and cost of extending the pilot effort statewide.

3.2.2 The Proposed Methodology

The Proposed Methodology is outlined in a separate document, 'Determining Altered Streams – Methodology' (Attachment A).

This methodology document describes the reference data sets to be used, the scales at which they should be applied, the standard ArcMap Tools and additional tools to be used to physically create the events, and a set of criteria to help determine when to define a stream segment as 'altered' and how to assign a confidence level.

All NHD Flowline segments are assigned an 'event' that identifies them as either 'Altered' or 'Natural'. The key to the criteria for determination is a list of 'rules of thumb' for determining altered/natural, a flowchart which outlines a sequence for applying those rules, and a confidence level that can be assigned based upon how many of the criteria are applicable to the determination. The purpose of the flowchart and the confidence level assignments is to try to create a quantitative, repeatable, method that, used by different people, would produce similar results.

Most often the determination is obvious from looking at the imagery. The determinations that are not obvious take most of the time. The flowchart and criteria list are meant to provide systematic guidance for those stream segments where the determination is not obvious to the eye.

3.2.3 Additional Reference Data Sets

The NHD 'Canal/Ditch' feature type coding for Flowlines was not considered to be the final arbiter for making the 'Altered/Natural' designation because the NHD was generally based upon the linework on the USGS 1:24,000 quadrangle maps, which can be many years out of date. Reasons for not using this feature type coding include –

- Originally interpreted incorrectly when mapping
- Data capture errors when going from map to initial digital to NHD
- Changes on the landscape (primarily ditching) since the maps and NHD were created.

To help create the 'Altered/Natural' event designations, LMIC used the following additional data sources:

- **DNR and USGS dams:** Point symbol data from the DNR Dam Inventory and the Dam Point Event Feature Class in the NHD.
- **Geographic Names Information System (GNIS):** line and point symbols with labels visible.

- **Digital Raster Graphic (DRG):** As a reference, 1:24,000 is the most important. This represents the map that the NHD was most likely originally created from.
- **Imagery – 1991 – Digital Orthophoto Quadrangle (DOQ):** These black and white photos often show the best contrast between water and dry land. Also, the photos were captured in spring, when the most water is likely to be visible on the landscape.
- **Imagery – 2003 Color Farm Services Agency (FSA):** Although not as recent as the 2006 color FSA imagery, it is more complete and has better resolution (1-meter resolution).
- **Imagery – 2006 Color Farm Services Agency (FSA):** Most recent imagery, although not as high resolution as 2003-2004 color FSA and not complete across the state.

Note: Updated color, 1-meter resolution Farm Services Agency imagery will be produced statewide for 2008. This full data set will be available by spring, 2009. Subsets of this data may be available as early as fall 2008.

3.2.4 Recommended Map Scale

At small scales (depicting a large area) many features will look like a straight line. At very large scales (depicting a very small area) grid-based reference data sets become fuzzy. Part of the research was to determine an appropriate scale for viewing the data sets. Experience on this project and other hydrography-related projects indicated that working within 1:5,000 to 1:10,000 scales seemed to work best. Scales less than 1:10,000 generally do not show enough detail on the imagery, and scales much greater than 1:5,000 tend to make the imagery too grainy and indistinct for differentiation of altered from natural streams.

3.3 Test/Modify Event Creation Tool

There are several tools available for creating events:

- The PC-RIT or PC-based Reach Indexing Tool (an ArcView tool developed by USEPA that creates events, using shapefiles as the base).
- The Hydro Event Management (HEM) Tool developed by the Pacific Northwest Hydrography Framework group that creates events on a personal geodatabase.
- Native ArcMap tools for creating linear events.

LMIC decided to use the HEM tool for this project. The HEM tool is considered the tool of the future for creating events based on the NHD. It creates events consistent with the current NHD event format. Although the tool is not yet functionally complete, the linear event functions currently in the tool were evaluated as sufficient for this project.

The HEM Tool enables the user to select features (NHD Flowlines) from the NHD and use them to create events. The events are defined in terms of NHD reaches and measures along the reaches, but are stored as separate features.

In order to easily collect the additional information for each event that MPCA had identified in the requirements, LMIC developed an add-on toolbar to use with the HEM tool. This 'Altered Events' toolbar has several features:

- Buttons to automatically assign to a selected stream segment a designation of 'Altered' or 'Unaltered' ('Natural').
- Buttons to automatically assign to a selected stream segment a Confidence level. These confidence levels are 95+% (high), 75% (medium), and 55% (low).
- A button to indicate whether the NHD feature needs to be edited for this particular stream segment. This just indicates on the event that the underlying NHD feature needs some type of geometric or attribute change; it cannot edit the NHD itself.
- The ability to add comments.

Use of the toolbar – and a graphic of the toolbar - is further described in the methodology document.

Note: Loading the Altered Watercourse toolbar is currently a very manual process. Project staff was unable to get the toolbar to compile so that it could be easily loaded as a ***.dll****. Consultation with the ESRI Help Desk did not provide a ready solution. To bring this process into production mode, this situation needs to be remedied.*

3.4 Test Methodology; Create and Evaluate Events

3.4.1 Event Creation

Once the basic methodology was well developed, LMIC tested the methodology by creating events over portions of three subbasins that represented different hydrologic regimes across the state. The events created designated NHD Flowline segments as 'Altered' or 'Natural'. The intent was that all stream features in a study area get assigned a value, so that there is full coverage over a study area. Events were created for over 1540 kilometers of streams in these three test subbasins, and average coverage is 26.6% of each subbasin.

Subbasin	Name	NHDFlowline Total (km)	Altered streams completed (km)	% of Subbasin Completed
07010204	N. Fork Crow River	2,576.365	497.619	19.3%
07020006	Redwood River	1,551.554	588.365	37.9%
07030004	Snake River	1,662.633	455.547	27.4%
Totals (KM)		**5,790.552**	**1,541.531**	**26.6% (average)**

Graphics of the results of the event creation are included in Section 3.4.2, which discusses the quality assessment of the event creation.

3.4.2 Quality Control Review of Event Creation

There are several methods that might be used to do a quality control review of the events created using the Altered Watercourse Event Methodology. The following were discussed as part of this project:

- Have different people create events using the methodology for the same area, to see how closely different people would come to making the same determination.
- Have a single individual do the determinations from upstream-to-downstream and from downstream-to-upstream – to see if the results differ.
- Compare the results obtained using this methodology to field information that could be used for quality control. The MPCA has made on-site determinations on 'altered' status for point locations on almost 2500 Stream Habitat Evaluation Areas. This information was available in a database, from which LMIC was able to create GIS points for comparison with the event linework.
- Compare the results obtained using this methodology to the base information on the NHD (the distinction of Feature Type on the NHD between 'stream/river' and 'canal/ditch') – and evaluate the differences.

3.4.2.1 Multi-person Evaluation of the Same Areas

Due to budget constraints, LMIC did have different staff people go over the same areas. It would still be worthwhile to do this – perhaps as MPCA staff tests the methodology more widely. This is discussed under 'Next Steps'.

3.4.2.2 Upstream/Downstream Evaluation

The main LMIC staff person developing the methodology tested some areas in an upstream direction and others in a downstream direction. He did not feel that it made a difference in the determinations. However, this is something that could be tested further. This is discussed under 'Next Steps'.

3.4.2.3 Comparison with MPCA Site Assessment Data

The Minnesota Pollution Control Agency had a database which they felt would provide a good check on this methodology. MPCA has a database of information associated with Stream Habitat Evaluation Areas. As of early June, 2008, the database contained information on 2491 Stream Habitat Evaluation Areas distributed across the state. Information collected in these evaluation areas includes an onsite determination of whether this stream segment is a natural or an altered stream. LMIC obtained from MPCA a subset of that database, *'SitesWithChanEval.xls'*, which contains the stream

evaluation segment ID, the point location of the determination, and altered/natural onsite determination.

LMIC initially identified stream segments (assessment units) where MPCA had made habitat evaluation assessments in order to make sure that the subbasins selected for the pilot and the areas chosen for event creation within the subbasin had field data that could be used for quality control.

Once the altered event files had been created for the three subbasins, LMIC staff compared the Altered/Natural Event determinations against the MPCA Onsite Assessment points. Correlations appeared to be good. Comparisons for each subbasin are illustrated and discussed below. Graphics are also reproduced at full page size in Attachment B.

Legend for maps and map discussion below:

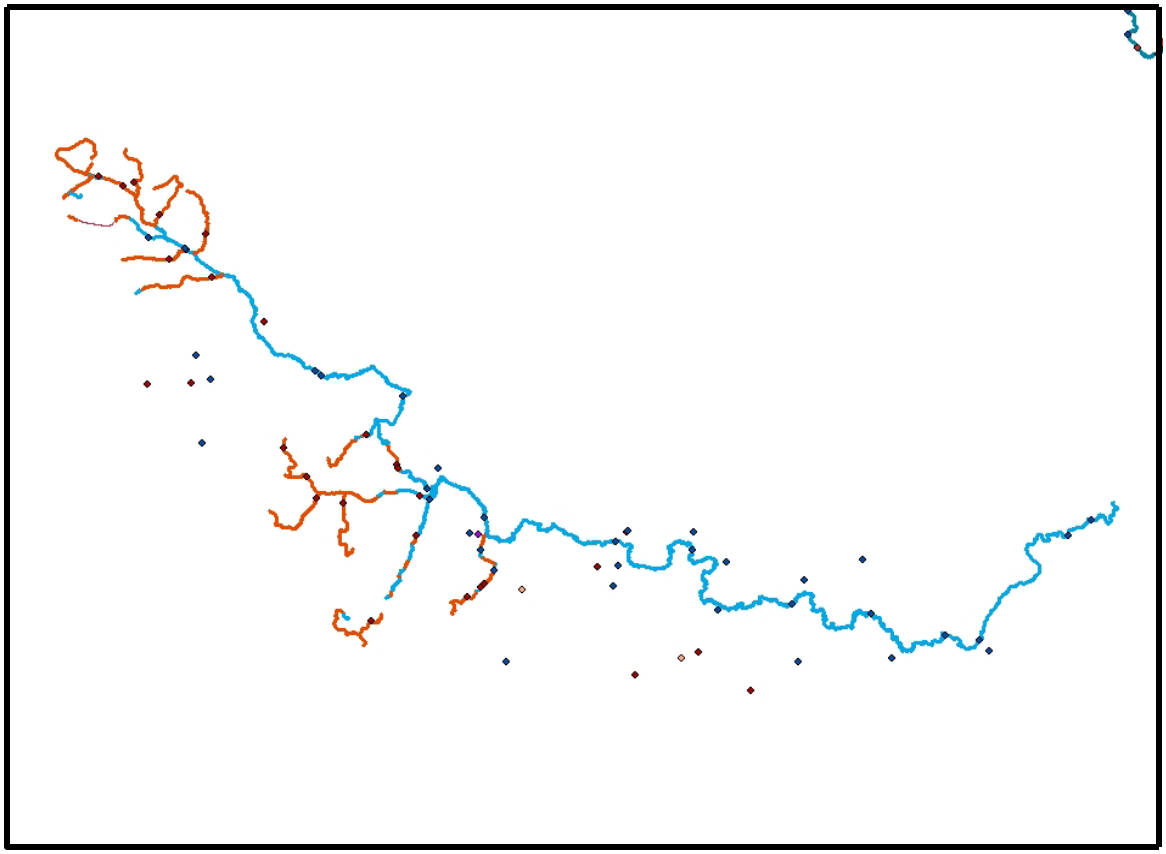
- ***LMIC – Natural Stream Event – blue line***
- ***LMIC – Altered Stream Event – red line***
- ***MPCA – Natural Site point – blue dot***
- ***MPCA – Altered Site point – red dot***

A high percentage of the time the designations of the points and the designations of the events were aligned: 90.2% for the Snake River Subbasin, 89.7% for the North Fork Crow Subbasin, and 85.2% for the Redwood River Subbasin. This is encouraging, but this data and these comparison graphics could use more scrutiny. For instance – in all of the cases where there were matches – would it be obvious to someone who did not use the methodology what the assignments should be – i.e., were the segments that matched the points obviously ditches or natural streams on the imagery? Did the methodology produce a match in those areas where the decision was less obvious and it actually needed to be used?

Conversely, it would be good to take a close look at each stream segment where the MPCA site evaluation designation and LMIC stream event designation did not match. Is there a discernible pattern to why they did not match? On the mismatches were the events assigned a low confidence level? Who is right and who is wrong? Both the graphics and the underlying GIS data could be used to help evaluate the matches and the mismatches.

Also, in how many of the mismatched cases is there an indication that the underlying NHD coding needs to be changed?

Results for North Fork Crow River – Subbasin 07010204



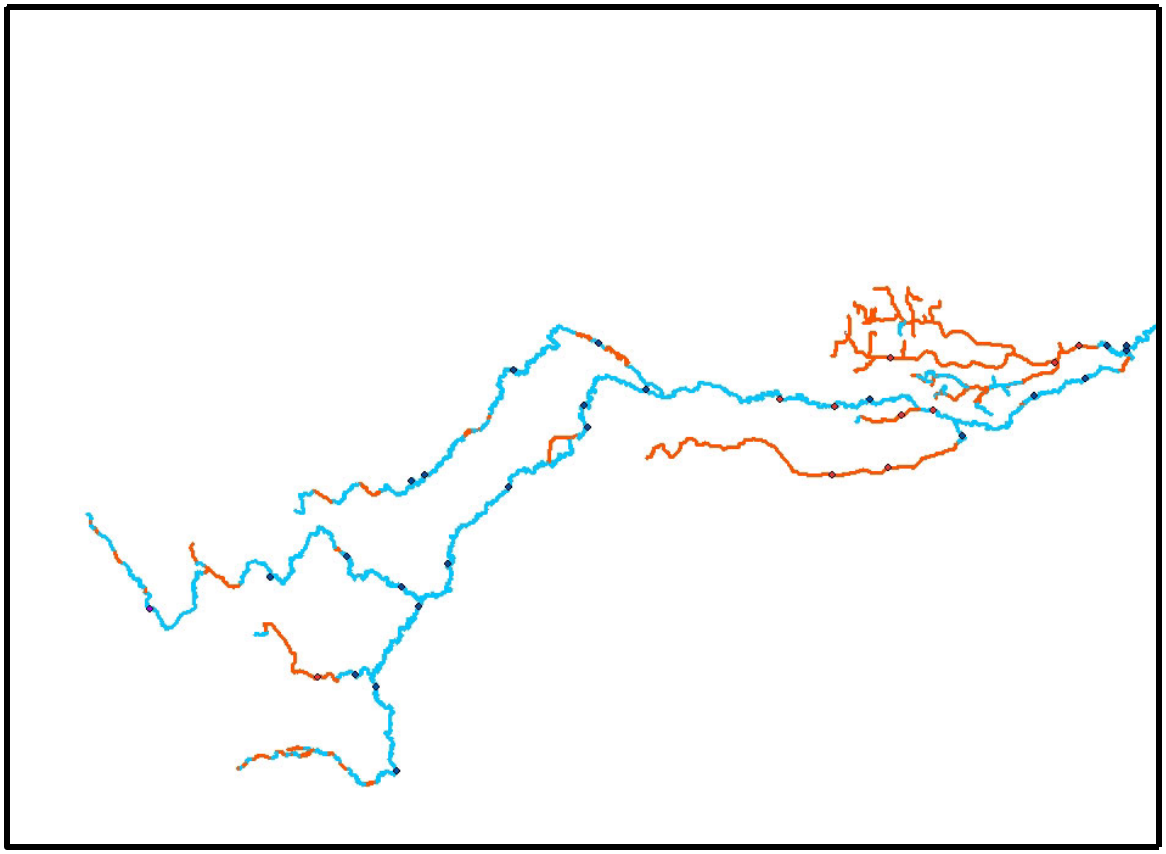
Subbasin	Name	NHDFlowline Total (km)	Altered streams completed (km)	% of Subbasin Completed	Hours to complete
07010204	N. Fork Crow River	2,576.365	497.619	19.3%	8

Subbasin	Altered Streams Completed (km)	Natural Streams (km - %)	Altered Streams (km - %)	Unassigned (km - %)
07010204	497.619	321.9 km – 65%	170.5 km – 34%	5.2 km – 1%

Subbasin	Altered Points/Altered Streams	Altered Points/Natural Streams	Natural Points/Natural Streams	Natural Points/Altered Streams
07010204	16	4	19	0

39 of the 89 Site Evaluation Points in the Subbasin were compared. 35 of the 39 MPCA Site Evaluation points agreed with the LMIC Altered/Natural Event designation.

Results for Redwood River Subbasin – 07020006



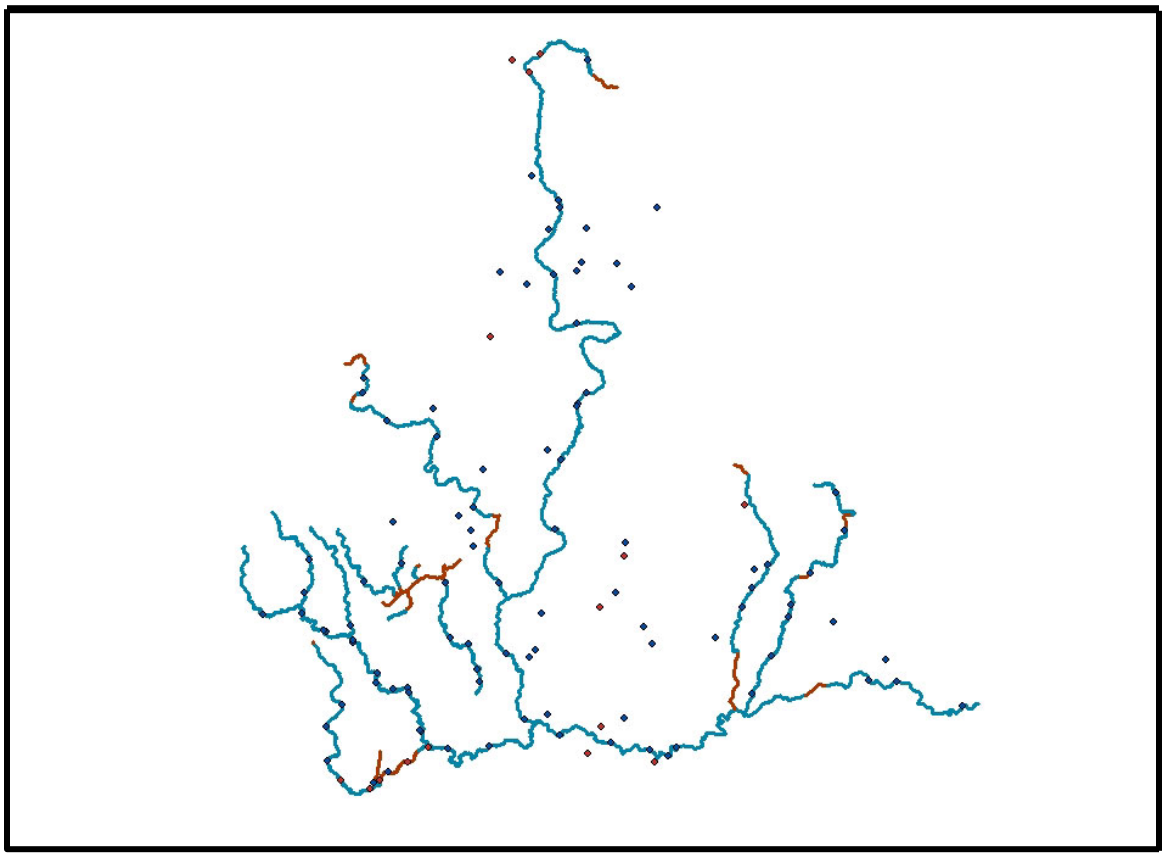
Subbasin	Name	NHDFlowline Total (km)	Altered streams completed (km)	% of Subbasin Completed	Hours to complete
07020006	Redwood River	1,551.554	588.365	37.9%	8

Subbasin	Altered Streams Completed (km)	Natural Streams (km - %)	Altered Streams (km - %)	Unassigned (km - %)
07020006	588.4 km	377.4 – 64%	210.3 km – 36%	0.6 km - 0%

Subbasin	Altered Points/Altered Streams	Altered Points/Natural Streams	Natural Points/Natural Streams	Natural Points/Altered Streams
07020006	6	4	23	0

34 of the 74 Site Evaluation Points in the Subbasin were compared. 29 of 33 MPCA Site Evaluation points agreed with the LMIC Altered/Natural Event designation. One MPCA point was ambiguous.

Results for Snake River Subbasin (St. Croix Basin) – 07030004



Subbasin	Name	NHDFlowline Total (km)	Altered streams completed (km)	% of Subbasin Completed	Hours to complete
07030004	Snake River	1,662.633	455.547	27.4%	11.5

Subbasin	Altered Streams Completed (km)	Natural Streams (km - %)	Altered Streams (km - %)	Unassigned (km - %)
07030004	455.547	407.0 km – 89%	48.5 km – 11%	0

Subbasin	Altered Points/Altered Streams	Altered Points/Natural Streams	Natural Points/Natural Streams	Natural Points/Altered Streams
07030004	2	5	63	2

72 of the 203 Site Evaluation Points in the Subbasin were compared. 65 of the 72 MPCA Site Evaluation points agreed with the LMIC Altered/Natural Event designation.

3.4.2.4 Comparison with NHD Feature Type Classifications

LMIC was also asked to compare the Natural/Altered Event designations with the underlying Feature Type Designation on the NHD Flowline (1-d stream feature). How well did the 'Natural' event designation match up with the NHD Ftype 'stream/river' and the 'Altered' event designation match up with the NHD Ftype 'canal/ditch'?

The methodology for comparing NHD altered/natural breakdown with Altered Events is as follows:

- Create Altered Events shapefiles for the three test subbasins.
- For the three subbasins, create NHD Flowline shapefiles containing only the stream segments in the Altered Events shapefiles.
- Create a frequency table for each Altered Events file. *Frequency variable is Event Type (natural or altered); Summary variable is Shape Length (meters).* Convert meters to kilometers.
- Create a frequency table for each NHD Flowline Event Subset file. *Frequency Variable is FTYPE, or Feature Type; Summary variable is Length_km.*
- Compare results and evaluate differences.

Known issues:

- Artificial paths on the NHD – which could be in either altered or natural areas – although they are probably natural most of the time

Frequency Data for the Altered Events Tables:

Subbasin	No Data Freq	No Data Length – m/km	Natural Freq	Natural Length- m/km	Altered Freq	Altered Length – m/km	Total Length- km
07010204	8	5.2 km	138	321.9m	144	170.5 km	497.6 km
07020006	1	0.6 km	185	377.4 km	159	210.3 km	588.3 km
07030004	0	0	141	407.0 km	55	48.5 km	455.5 km

Frequency data for NHD Flowline Event Subsets matching the Altered Events:

Subbasin	Connector (334) km	Canal/Ditch (336) km	Stream/River (460) km	Artificial Path (558) km	Total – km *
07010204	0.9 km	126.3 km	167.0 km	204.9 km	499.1 km
07020006	2.4 km	171.4 km	371.8 km	42.4 km	588.0 km
07030004	6.0 km	11.5 km	246.3 km	187.4 km	451.2 km

* *Note* – to create the flowline_evt files for each subbasin LMIC did a spatial intersect of the state NHD Flowline file with the Altered Events file for the subbasin, saved out the results as a shapefile, and projected to UTM. Since the spatial intersect brought along additional tributary features where they intersected the main flowline, these were manually deleted from the file before summarization. Then the frequencies were done. If there are discrepancies between the total kilometer length of features in the Altered

Events files and the NHD Flowline events files it is as a result of this manual deletion process – an extra feature was kept or a small feature that should have been kept in the file was dropped in error.

Comparison Table: Altered Events vs. NHD Flowlines:

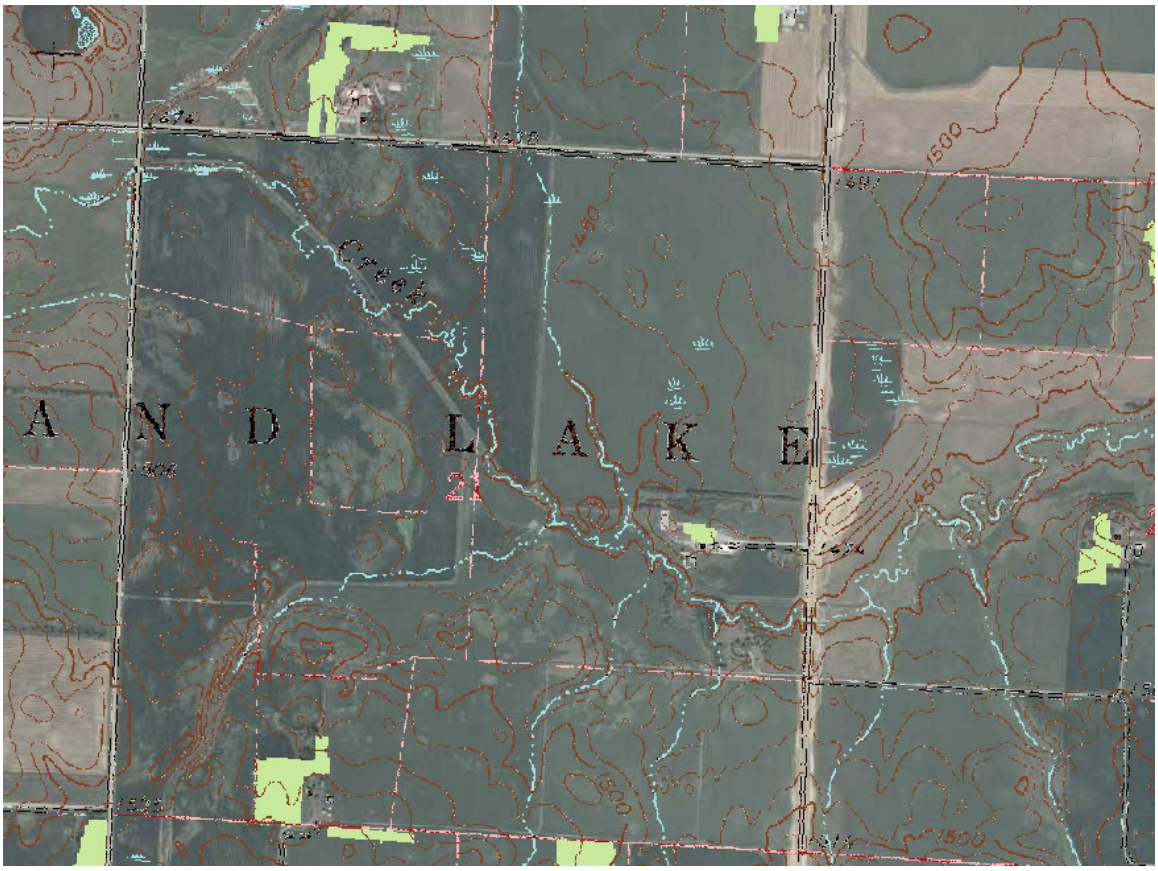
Subbasin	Alt. Events	Alt. Events	NHD	NHD	NHD	NHD	NHD
	Natural - km	Altered - km	Stream/River - km	Canal/Ditch - km	Artificial Path - km	Connector - km	Comb - km
07010204	321.9	170.5	167.0	126.3	204.9	0.9	371.9
07020006	377.4	210.3	371.8	171.4	42.4	2.4	414.2
07030004	407.0	48.5	246.3	11.5	187.4	6.0	433.7

Comparison Discussion:

It was difficult to make a direct comparison because of the way NHD Flowlines are coded. Whenever the watercourse feature is a two-dimensional feature, then the one-dimensional feature is coded as 'Artificial Path' rather than 'Stream/River' or 'Canal/Ditch'. In general, though, most artificial paths flow through features that are rivers rather than ditches. So it is useful to add those two features together for purposes of this comparison (see column NHD/Combined – or Comb - in the table). Ignoring minor codings such as 'not assigned' or 'no data' on the Altered Events side and 'Connector' on the NHD Flowline side, and acknowledging that this is generalized, there is still a significant difference in assignment, with significantly more kilometers of streams being assigned as 'Altered' in the Altered Event file than are coded as 'Canal/Ditch' in the NHD.

LMIC did a qualitative comparison by looking at some of the areas where a stream segment identified on NHD as 'Stream/River' is identified as 'Altered' on the 'Altered Event' file. In a number of cases – and as was to be expected – the NHD stream feature followed the DRG, which indicated a meandering stream on the map, whereas the 2003 and 2006 aerial photography indicated that the stream segment had been ditched. The example below – a segment of Threemile Creek in the Redwood River watershed - is typical.

The first image shows the DRG of the quad map superimposed over FSA 2003 imagery. The quad map indicates a meandering stream segment that is no longer there.



The second image shows the altered events linework which traces the NHD linework. However, the event type code indicates that the segment in red is altered, not natural. The Comments field says 'Replace stream with ditch'. Since the stream segment modification appears to be permanent, this change should be made on the NHD – replacing the linework to match the current ditch and changing the feature type code.

3.5 Project Reporting

Project reporting is to include this Final Report, a documented methodology (*Determining Altered Streams – Methodology* – Attachment A), and feedback meetings with MPCA. During the project period one meeting was held with MPCA to present the methodology and findings and discuss them with MPCA. Comments and questions raised in this meeting are summarized in Section 4 of this document.

3.6 NHD Updates

LMIC did not make any edits to the NHD in the course of this project. More time was spent in developing the methodology and developing the additional Altered Event toolbar, leaving no funding remaining to make updates.

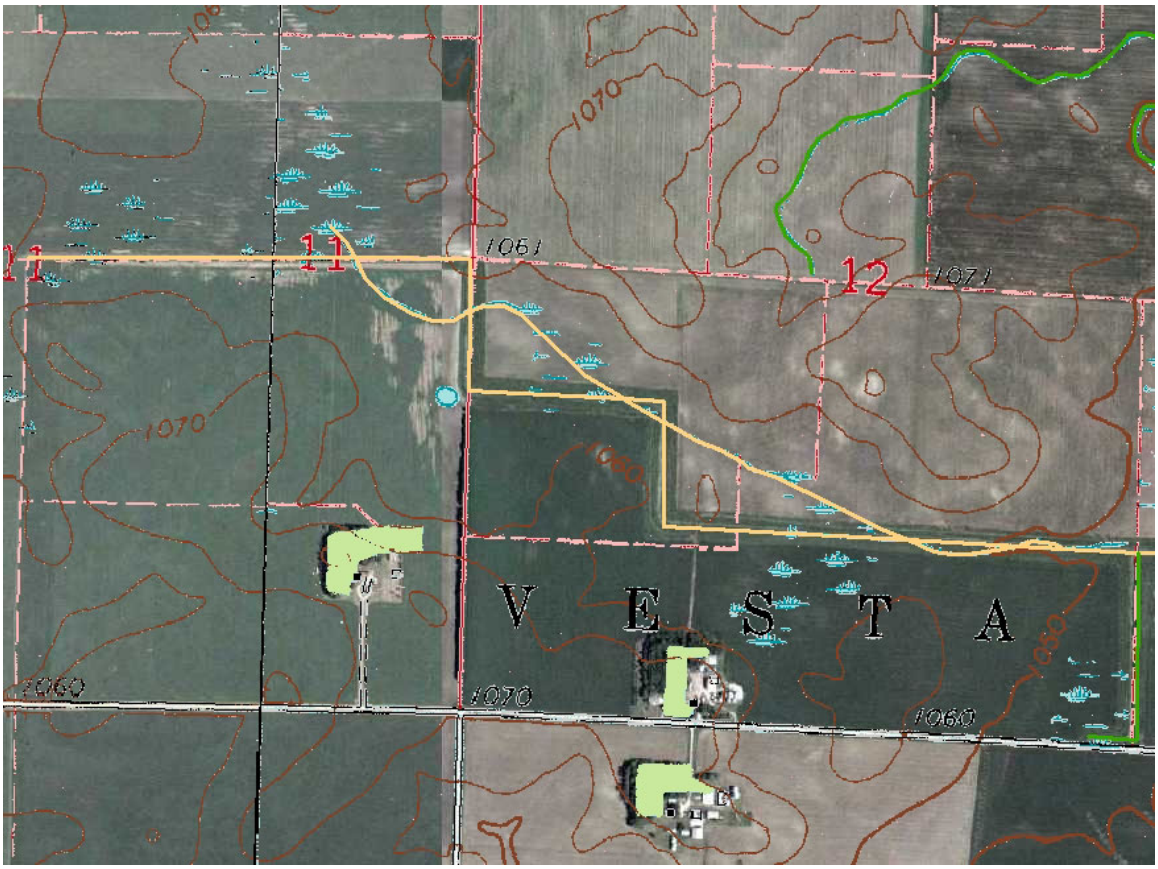
An evaluation of the Altered Events table attribute 'NeedsUpdate' for the three subbasins showed the following:

Frequency Table based on 'Needs Update' field on Altered Events Files:

Subbasin	OK (Code = 0) - km	Needs Update (Code = 1) - km	Total km	% of Reviewed Lines needing Update
07010204	**478.2 km**	**19.4 km**	**497.6 km**	**3.9 %**
07020006	**532.9 km**	**55.5 km**	**588.4 km**	**9.4 %**
07030004	**435.8 km**	**19.7 km**	**455.5 km**	**4.3 %**

The North Fork Crow River and Snake River Subbasins had around 4% of the linework needing a change of coding and updating of linework on the NHD. The second graphic under section **3.4.2.4** is an excellent example of the type of update often needed.

The Redwood River subbasin had a high percentage of NHD lines needing update – almost 10%. The graphic below shows a common situation in the subbasin and may indicate why the 'NeedsUpdate' percentage is so high. The original DRG shows a meandering stream; the NHD shows both the meandering stream and a ditch feature that gradually replaced the stream; current imagery indicates that the formerly meandering stream is now totally erased from the landscape. Since both the old stream on the NHD and the new ditch on the NHD are coded as 'NeedsUpdate' on the Altered Streams file, (with the comment 'Overlying Stream should be removed from NHD. It no longer exists per photos'), there may be some over-reporting – but it does indicate that more changes need to be made to the NHD.



4.0 Group Feedback and Remaining Questions

The following comments were compiled from the meeting with the Project Advisory Committee on June 17, 2008.

Key question to be answered: The key question this methodology needs to answer is "Is there evidence of a physical modification of the stream? (- i.e., was there a backhoe in there?)"

The methodology: The MPCA advisory group generally agrees with the methodology.

Possible additional criteria and data to be used?

- **County Ditch Inventories, where available:** Legal ditch records are available in every county courthouse. Only a few of the county ditch inventories have been made digital. These might be useful, with the caveat that not every ditch that was legally named was ever created.
- **Stream Sinuosity:** LMIC did some research into stream sinuosity but did not find any criteria they felt comfortable using. MPCA mentioned this in the review meeting and may have further information on this.

- **Nearby stream classification:** MPCA had looked at what was nearby – and how nearby streams of similar shape were classified. This technique did not work very well.
- **FSA 2008 Imagery:** This new data set will be available late 2008 or early 2009; if applying this methodology statewide it would be best to consistently use the newest imagery data available.

Altered Watercourses, Waterbodies, and Impoundments:

- The decision rule is to treat stream segments within impoundments upstream of dams as 'Altered' but to treat flows downstream of dams as 'Natural', while recognizing that flows downstream of dams are affected (in timing and volume) by dam operations. Dredged stream segments (e.g., downstream of dams in major navigation channels) are considered to be 'Altered'.
- Waterbodies are not being categorized as 'Natural' or 'Altered' at this time.
- MPCA's criterion for whether a Waterbody is a lake or a reservoir (natural/altered) is how long the water sits before being moved.
- MPCA may need a new category – impoundments – to handle reservoir/lake issues.
- Do designations need to be applied on stream flow paths through lakes?

MPCA Future Assessments:

- A new assessment method – Tiered Aquatic Life Use (TALU) – will likely be implemented by MPCA. Also, waterways may be assessed watershed-by-watershed, rather than stream-by-stream, as is currently done.
- Current MPCA Assessment Units for streams (AUID's) can include both natural and altered stream segments. MPCA could see value in assigning breakpoints of Assessment Units such that they contain only natural or only altered stream segments.

Additional attributes for Altered Events: - add a field for 'Observed'?

5.0 Extending the Project

5.1 Toolbar enhancements

The Altered Watercourse Add-On Toolbar should be modified so change the colors of the buttons that indicate 'Altered' and 'Unaltered': 'Altered' should be red. 'Unaltered' should be blue or green. This is more intuitive and is more in line with other MPCA reporting and mapping, where changed or degraded features tend to be shown in red.

Also, the problems with loading the Altered Watercourse Toolbar need to be fixed before any larger-scale use. Right now the tool basically has to be rebuilt on each ArcMap user's desktop because there is no easy way to load it. This needs to be resolved with the ESRI Help Desk because the current practice is not acceptable for porting the toolbar to multiple desktops.

5.2 Time estimates for completing the state

Once the basic methodology was well developed, event creation was done in a timed manner so that LMIC could extrapolate out to completing the state.

This is a bit imprecise because most areas are very easy to categorize, and a few areas are difficult and take up most of the time. However, LMIC and MPCA needed data that would provide a basis for statewide extrapolation. An assumption made is that the different regimes tested in the subbasins upstream of Lake Pepin would be representative of the state as a whole.

Subbasin	Name	NHDFlowline Total (km)	Altered streams completed (km)	% of Subbasin Completed	Hours to complete
07010204	N. Fork Crow River	2,576.365	497.619	19.3%	8
07020006	Redwood River	1,551.554	588.365	37.9%	8
07030004	Snake River	1,662.633	455.547	27.4%	11.5
Totals (KM)		**5,790.552**	**1,541.531**	**26.6% (average)**	**27.5**
Average		**~56,000 m (56 km) per hour**			

Based on a completion rate of 56 kilometers per hour and based on a total NHD Flowline length of 167,662 kilometers, completing the entire state would take 2994 hours or approximately 75 40-hour work weeks.

MPCA staff was interested in what experience level would be needed by staff that performed the Altered Events work. At LMIC this development work was done by a GIS professional accustomed to working with hydrography data. The methodology was intended to be used by any GIS-knowledgeable person - but it is recognized that some hydrologic knowledge may be necessary for the best interpretations. Another approach might be to have a GIS technician do the base assignments, then have staff with more of a hydrology background review any Altered Events assigned a low (55%) confidence.

6.0 Next Steps

These possible 'Next Steps' were identified at the Methodology Review meeting in June 2008:

- LMIC Distribute the HEM Tool, Altered Event Toolbar, Pilot Subbasin Altered Event Data and QC Data to interested MPCA staff. (Distributing the Toolbar would require a tool fix, as described in Section 3.3.)
- MPCA staff use the tools to create Events for additional test areas (and also possibly for the same areas) to provide more feedback on the methodology.
- MPCA look at the Events created in this pilot project and the quality control data – looking specifically at areas where the Altered Events Pilot and the MPCA Site Assessment process did not assign the same values, or where the confidence levels assigned to the Altered Events were low.
- Present the methodology and results to a broader audience, including other agencies, and to others affected by the determinations. Elicit feedback from that audience. There would be value in presenting the methodology and its results to staff at other agencies, and obtaining more feedback, to generate more buy-in for the project and its results.
- Discuss refinement of the methodology based on feedback from the previous steps and possible additional data.
- Investigate additional data resources and process refinements, as identified in Section 4.
- Explore methodologies for identifying headwaters of streams in a scientific and consistent manner across the state.

7.0 Conclusions

A comparison of the Altered Event results created by this methodology to the NHD Flowline Feature Type 'Canal/Ditch' confirms the assumption that there are significantly more altered watercourses in Minnesota than are currently categorized as such on the NHD, and that using this methodology is superior to just using the NHD Feature Type to define an Altered Watercourse. This is because the state's NHD linework is largely still based on the 1:24,000 DRG's and does not reflect newer imagery.

This methodology was well-received by the MPCA Advisory Group for the project, and appeared to do a good job of classifying altered streams when compared to available quality control data. MPCA staff members that have experience with this classification are in general agreement with the steps in the methodology. However, before being applied to the state as a whole, it would be valuable to have more hands-on testing by the individuals that need the Altered Watercourse designations, and a further evaluation of those areas where the designations according to this methodology and the MPCA's on site assessment designations do not agree.